RAILWAY ENGINEERING AND MAINTENANCE OF WAY.

WITH WHICH IS INCORPORATED

ROADMASTER AND FOREMAN

BRIDGES--BUILDINGS--CONTRACTING--SIGNALING--TRACK

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CONTENTS.

The Railway Situation

It seems as though the hearings before the Interstate Commerce Commission have degenerated into the proceedings of an ordinary criminal court if the idiosyncric peregrinations of a man acting purely as a prosecutor instead of an arguer, and a third rate politician who has appointed himself—as there is no evidence of any one else having done it—as representative of the commissions of several of the western states can interfere with the deliberations of this body at such a crucial time as this. This commission is supposed to be one of the most dignified—and is certainly one of the most powerful—of our governmental institutions. It seems evident that the commission instead of lending a perfectly unbiased deliberation to the basic facts at issue—the raise in rates and the credit of the railways—is using the present unusual situation to enhance the further governmental control of the railways. That is, to bring about the means of controlling any further issuance of securities, of one type or another, against the properties of the railways. This in itself is commendatory, for the actual railway executives would welcome a change that would not cheapen the earning power of their properties by the load of useless securities issued for the pecuniary gain of a favored few. But this is neither the time nor the manner for the commission to bring about a reform of this sort. A change like this will have to be brought about gradually, except in a few isolated cases, or a great financial crisis will occur which will hurt the innocent investor far more than the financial powers. Besides, there are not many of the American railways that are now burdened with these overissues, and it is neither justice nor good judgment that the fabric of the whole transportation system should be jeopardized at this time simply to curtail the irresponsible few. During the deliberations the "prosecutors of the railways," in presenting their claims to the commission, have argued that the railways are not like "other industries." This is true, but they seem to have overlooked exactly what type of industry they are. A railway is a manufacturer of, and sales agent for, transportation, differing from "other industries" in the fact that the cost of manufacturing is governed by the labor unions and the selling price *fixed* by the government, in addition to being a public servant with all the additional restrictions that that entails. There is no other manufacturing industry in the world that could exist surrounded by such a multiplicity of restrictions. The fact that the railways are public servants and reach into all the ramifications of public life, industry, existence, and even enjoyment, should suffice for the government to help them, whenever needed, in the proper manner, instead of making them less efficient by constantly rendering decisions that will inevitably impair their service. The American people receive better service as to both freight and passenger service than any country in the world. And this service is rendered better as to length of time consumed in long journeys and cheaper per ton of freight and per passenger. As one of our contemporaries states, "It is obvious that the railways would not be before the commission except for the fact they are in an entirely different situation from 'other industries.' What they may charge for their commodity, transportation, is fixed by the will of the commission. Any commissioner who should be capable of losing sight of this basic factor, or, worse still, of ignoring it, would be unfit for a place on the commission." It has been published that the commission did not

have the power to allow an increase in rates. We do not pretend to be familiar with legal technicality, phraseology and procrastination, but if the commission has not this power we would be extremely grateful to this profession to enlighten us as to who has. We have been told that certain fundamental laws of right and wrong are the same in most modern civilized countries. In another part of this issue we republish an account of the action of a government in arbitrarily raising both passenger and freight rates on a *government owned* railway. These rates were raised respectively 20 and 10 per cent and not 5 per cent. If other governments do this, why cannot ours when the necessity arises? The daily papers state that it will be thirty days after the closing of testimony before the commission renders a decision. If this is so it is another glaring example of the inefficiency of the commission, concerning which we have written before, and argument for a change in the personnel of the commission by the appointment of capable railway men and the elimination of some of the legal lights. The people are beginning to grasp this fact, and only last week there was a storm of protest in the State of Maine because too many lawyers and politicians were being appointed on the State Railroad Commission. It is high time that those with the appointive power heed "the handwriting on the wall."

Government Ownership

The suggestion by Mr. Ripley of the government control of the railways under a regional "group" system with one or more government representatives on each board of directors, backed by a federal guarantee, has caused more expert deliberation and comment than any government controlled proposition for the railways yet promulgated. Coming from such an authoritative source, it has received more than passing consideration by those capable of judging and has caused those in authority, who have been neutral and inattentive, to concentrate their attention on the matter for the first time. It seems to us that this would be an extreme manner of circumventing the plan of the Interstate Commerce Commission of acquiring more governmental control in another manner, and also of hindering future appeals for governmental aid. The procrastination of the commission in either rendering a decision or showing any signs of rendering aid was undoubtedly the prime factor in causing Mr. Ripley to reach his decision and make the proposal. We are not ready for complete government ownership or control and this has been evidenced lately by the refusal of the government itself to purchase an Alaskan railway at a perfectly reasonable price, when it was offered to it by corporate interests. The American people want service, and that is more paramount to them than the actual cost of the service. In another column we reprint an article on the cost of operation of Australian government owned railways which is extremely interesting as compared with cost and service rendered by private enterprise. In England the telegraph, postal and telephone service is owned and operated by the government, and although it is sold to the people at less cost than here the service is inefficient and characterized by the recipients as "abominable." If such a thing as temporary government ownership could be tried in this country for a short period of five years or so, with our present system of politics and political henchmen, we are certain that the American people would render such a howl of protest over the service rendered that the government would be glad to turn back the properties. If the regulation of the issuance of securities, the proper method of operation and the installation of proper equipment and safety appliances were controlled by a government board, the government would have all it could do to take care of the best interests of the people at large.

Physical Valuation

It was March 3, 1913, that President Taft signed the bill authorizing the physical valuation of the property of the common carriers. At that time the so-called government experts estimated it would take five to seven years to complete the work, would cost the government in the neighborhood of $7,000,000.00 to $8,000,000.00 and the railways in the neighborhood of $11,000,000.00. At this writing, one year and eight months after the bill became a law, the valuation of less than 5,000 miles has been completed and none of this has been accepted by the government, state governments or railways as final, according to the wording of the bill. What is wrong? At this rate it will take the government about seventy-five years to complete the work, and the experts *who know* state it will cost in the neighborhood of $50,000,000.00. We have not attempted to compute the cost to the railways as this will be governed largely by the demands of the government representatives in making the valuations. From our observation it strikes us that a great deal of this delay and cost has been due to the method of selecting the staff of the government for doing this work. Although there are some excellent men of the proper training and experience on this staff their are many others that neither by training, railway, or engineering experience, or ability, have any right whatever on this staff. Another reason for this poor selection has been the fact that the Interstate Commerce Commission has in no instance, in the various so-called senior positions, offered to pay the salaries advertised. The consequence is inexperienced and inferior men have accepted some of these positions. One of the engineering board remarked that engineers ought to accept these positions at a less salary for patriotic reasons. This was singular, as this particular member of the board is now drawing from the government the highest salary he has ever drawn and in all probability the highest he would ever have attained in following his regular branch of the profession. The claim has been made that the commission has not received sufficient appropriations from Congress to adequately carry on the work. If this is correct it is high time that the American people awake to a realization of what is going on and compel their representatives to give closer attention to the business end of their administrations and save the country great sums of money, for the longer this work is dragged out the more it is going to cost the government and the people.

The United States Civil Service Commission

In a recent issue we called attention editorially to the inadequacy of the working of the United States Civil Service Commission in properly selecting applicants for the senior engineering positions to take the physical valuation of the railways under the Interstate Commerce Commission. On another page we publish an article that was contributed, entirely unsolicited, which deals with this question in detail and gives concrete examples. The suggestion in this article of the proper handling of papers by the examiners is an excellent one, as it

takes into consideration a most human fallibility, and it behooves government administrations to give this matter careful and deep study if the letter of the excellent Civil Service Law is to be carried out. The methods that were pursued and the results attained in these examinations have produced many ridiculous results, and, besides causing severe criticism by unbiased engineers all over the country, have seriously impaired the efficient working of the government machine. The crux of the matter is that this is the biggest work ever undertaken by this commission and with a higher type of trained men of larger experience than they have ever before dealt with, and they and their examiners have been found wanting in many instances. The fault is in our political appointive system and establishing men on commissions who have not had sufficient experience in dealing with the intricate technical problems they are now becoming involved in. We will never attain efficiency until these appointees are men of special training and experience and until the positions are made attractive enough pecuniarily and permanently to procure men of that calibre.

PENNSYLVANIA DEPARTMENT OF LABOR AND INDUSTRY.

Harrisburg, Pa.

In accord with the unanimous vote of the first Pennsylvania Industrial Welfare and Efficiency Conference, held in Harrisburg last year, John Price Jackson, Commissioner of Labor and Industry, has issued a call for a second conference, to be held in the State Capitol at Harrisburg on the 17th, 18th and the 19th of November, 1914. This conference is held under the auspices of the Pennsylvania Department of Labor and Industry and the Engineers' Society of Pennsylvania. The purpose of the conference is to enable the employers and employees to work out together the great problems before them with reference to increasing the welfare of the employees and the prosperity of the industries.

The conference last year was the most unique and helpful of its kind ever held in the United States. It was attended by approximately two thousand persons, many of whom were leaders in the labor and industrial world. The gathering this year bids fair to have an even larger attendance and to create even more interest than that of last year.

The first session of the conference will be called at 10 a. m. on Tuesday, November 17th, and the meetings will close at 5 p. m. on November 19th. The various sessions of the conference will be held in the State Capitol, Harrisburg. In connection with the conference proper will be held an unusually effective Safety, Welfare and Efficiency Exhibition, which bids fair to be the best of its kind ever held in this country. This will open on the morning of November 16th and close on the evening of November 20th.

The commissioner firmly believes, both from the unusual value of the conference last year and the even more positive purposes of the present conference, that a very great amount of work can be accomplished this year. He therefore earnestly calls upon every broad-minded citizen of the commonwealth who is interested in industrial affairs to come to Harrisburg at the time of the conference and take an active part in the proceedings.

The Nashville, Chattanooga & St. Louis Railway has completed plans and designs for an interlocking plant at Sherwood, Tenn., which they will build with their own forces. The design comprises a number of interesting features in the way of special circuits designed to meet operating conditions peculiar to the plant. The Pflasterer Controlled Manual apparatus, which has been in use since 1911, will be extended.

Twenty Years Ago This Month

(From the Files.)

D. J. Whittemore, chief engineer of the Chicago, Milwaukee & St. Paul, presented a paper upon the form of railway excavations and embankments before the annual convention of the American Society of Civil Engineers. It was very brief but brought out an extended discussion.

The business of the country, considered as a whole, continues depressed and unprofitable, says a writer in the *North American Review.*

A trackman in South Dakota complains of the unnecessary length of track bolts and says that a saving of 25 per cent in material could be made.

C. B. Lintell, roadmaster of the Boston & Albany, was awarded first prize for superiority in track work in the annual distribution of prizes.

The officials of the Pennsylvania have decided to increase its standard of weight of steel rails on its main line from 85 to 100 pounds.

At the roadmasters' convention in New York the Pennsylvania Steel Co. exhibited a guard rail clamp especially adapted to securing the rails with any desired space between their heads. It was designed by G. W. Parsons of that company.

The plans of the various railways for track elevation at Chicago are being completed.

The second annual convention of the Roadmasters Clerks' Association was held at Chicago with P. D. Reith presiding.

The Buffalo & Susquehanna, a new line in Potter and Clinton counties, Pa., has been opened for traffic. M. E. Olmstead is president of the road.

The Victoria bridge, a long tubular structure carrying the Grand Trunk over the St. Lawrence at Montreal had no provision for ventilation as originally built under the direction of E. P. Hannaford, chief engineer. The work of cutting out portions of the top plates and strengthening the bridge to compensate for this, was done.

A novelty in the form of pressed steel fence posts is being placed on the market by the Avery Stamping Co. of Cincinnati.

The committee of the American Railway Association on signal-light colors says blue might possibly be used for the caution color if the flame were pure white. A pure white flame, it is admitted however, is not available.

The Western Union Telegraph Co. has just completed the stringing of a new copper wire from New York to San Francisco and a message was sent over it using but two repeaters.

An audible electric block signal apparatus called the Cornell system, was tested on the Philadelphia, Newtown & New York, near Fox Chase, Pa.

A highway bridge, recently built by J. E. Greiner, engineer of bridges, of the Baltimore & Ohio, is composed largely of old rails and scrap material. The top chords and inclined braces are made of rails in pairs and the bottom chords of a single rail. The bridge was built in the repair shops of the company and cost but $9.18 per foot, including the cost of removing the old structure.

F. A. Delano, superintendent of the Chicago terminal of the Chicago, Burlington & Quincy, read a paper at the American Railway Association of "English Signal Practice," which was a very complete summary of the subject.

The Auto-Pneumatic Railway Signal Co. of Rochester, N. Y., will install an interlocking plant at the crossing of the Delaware, Lackawanna & Western and the Western New York & Pennsylvania at Mt. Morris, N. Y. This type of apparatus, which is wholly pneumatic, has been in use at Buffalo for more than a year and has made over 150,000 operations at that place without failure.

The necessity of suppressing train robberies is being discussed to quite an extent. A large number of robberies have occurred.

TESTIMONY OF SAMUEL REA, PRESIDENT PENNSYLVANIA RAILROAD SYSTEM

Given before the Interstate Commerce Commission at Washington, October, 23, 1914.

Mr. Samuel Rea, President of the Pennsylvania Railroad System, in testifying before the Interstate Commerce Commission in the matter of increased freight rates, said:

"The railroads have appealed to the Commission to modify the order made last July, because since then certain facts have transpired and certain events have occurred, in the light of which the present situation of the railroads should be judged. We consider this situation a sufficient reason for the Commission to grant what the railroads ask.

"Among these new factors are:

"First—Complete figures covering the financial results for the fiscal year 1914, which are now for the first time available in this case; also statements of operation covering the months of July and August of the present fiscal year.

"Second—the European War.

"The Commission had before it, at the time the hearings were closed, figures from which it made an estimate of the operating results for the twelve months ended June 30th last. The Commission in its report took cognizance of figures covering eleven months of the twelve, as far as certain operating results were concerned, but in another, and a much broader sense, the complete 1914 results, showing as they now do the return on the investment, are new and of the greatest significance in connection with this petition. The Commission did not have, and could not have had before it, at the time it made its report in this case, the information necessary for it to appreciate fully the conditions of the transportation industry as now disclosed in these complete returns.

"In the fiscal year 1914 the decrease in the volume of business of these carriers was only about 3½ per cent from the highest level in their history, viz., in 1913. Yet at the end of 1914 the owners of these properties find the return upon their property investment at the lowest figure for fifteen years, lower than in 1900, when the industry was lifting its head after the great depression of the nineties; lower, indeed, than in the two years 1898 or 1899, which the Commission in its recent report excluded from comparison on the ground that those were years of business depression. A record such as this clearly indicates something radically wrong with the underlying conditions of the railroad business.

"The Commission in its report recognized the need for more revenues for these carriers. The complete 1914 financial returns clearly indicate that this necessity has now become vital.

"The operating returns for July and August add to the seriousness of the situation. For those two months the decline in gross earnings averages about 6 per cent as against a loss of less than 3½ per cent for the entire year 1914. The companies have been compelled, by reason of this, to continue the forced retrenchment in operating expenses.

"That retrenchment policy and practice will not produce real savings in expenses or real increases in net profits, for sooner or later the property and equipment must be brought up to standard. It may be that since June 30th, as the result of drastic retrenchments, some railroads will show slightly better net operating results. Such apparent improvement is of little actual benefit. It must also be remembered that the railroads are continually increasing their investment in road and equipment, on which increase they should earn an adequate return.

"Such is what I conceive to be the immediate importance of the 1914 and later returns.

"With regard to the European war, the question has naturally suggested itself: In what respect may its effect upon the railroads be regarded as peculiarly justifying them in asking for relief? The war, it has been said, brings burdens for all. Why should not the railroads consider the burden that it brings upon them as one which they should themselves shoulder without seeking to be relieved therefrom?

"Had the railroads before the war been in a sound, healthy condition, it might have been claimed that in so far as their volume of business was temporarily affected thereby, that burden was one which the railroads should have assumed, just as they had previously borne the fluctuations that had occurred from time to time in their business resulting from industrial and commercial vicissitudes.

"The railroads, however, are subject to regulation by public authority covering not merely the rates they shall charge, but many of the conditions affecting their operating costs and methods; they are and have been placed in a category entirely distinct from that of industries not subject to such regulation. They should be in such a position of health that they could withstand their proper burden during a period of general adversity such as this, so that with an improvement in business they might be in a position to render a proper and adequate service, and earn a fair return on their property investment.

"In view of what the Commission before the war had found to be the basic condition of the railroad industry with reference to rising costs and inadequate returns, it must be admitted that the war has brought a special aggravation of a situation peculiar to the railroads; a situation which had already been adjudged as in need of relief.

"The conceded inadequacy in the net operating income of railroads in Official Classification Territory before the war resulted primarily from increased cost of maintenance and operation coincident with a large increase in property investment. On top of this the war has already caused a large increase in the rate of interest demanded by capital—how much it is hard to say with certainty, but we know that an enormous destruction of wealth is in progress, and that must have an inevitable effect on the supply of capital, and therefore on the rate of interest. Whatever increases the cost of capital increases the cost of transportation.

"The question here is not whether the Commission shall advance rates merely in order to sustain security prices against selling by holders, abroad or at home, or even to continue dividends; although important, that is but one phase of a big question. This petition is for an advance in rates which it is hoped will result in enabling them to provide the proper facilities, improvements and service needed by the public, and earn an adequate return on property investment.

"The abnormal conditions brought about by the war affecting so directly the ability of any borrower to secure new capital, and requiring forcible reduction of all expenses and husbanding all resources, are strong reasons for remedying, at least in part, and doing so as quickly as possible, the fundamental unsoundness—war or no war—that had been previously shown to exist in the railroad industry.

"I feel that the existence of a crisis in the affairs of these railroads can no longer be questioned. Having earned a return of only 3.99 per cent in 1914 on the property investment, with operating revenue progressively diminishing since the close of the fiscal year, with practically all improvement work suspended, with forces largely reduced, with passenger and freight train service curtailed, and maintenance of roadway and equipment deferred, this is a time for very definite and certain relief. I am convinced that in addition to whatever may be eventually realized from the methods for obtaining additional revenues suggested tentatively by the Commission, the situation is one that calls for positive and immediate treatment on the broadest possible scale within the powers of the Commission."

HOW RETRENCHMENT HITS THE SECTION FOREMAN.

(Courtesy of W. E. Harkness, Eymon Cont. Crossing Co.)

Maen god Birt, wat is de matter mit Bill

Ich ask for 10 pound Nails Loooong ago

Ich need 2 Sett No. 7 frog bolts way Loooong ago

Ich ask for Latarn Globe So Long ago

I Order bout over 3 weeks ago 2 Duzand + Bolts for P. F. +; Ich ask by Mail bout 1-2-3 nearly 4 dimes, No git; No-got;

Ach Bill wan der is a bad Shpot Ach god how de Holler

Now der P. F. must have some + Bolts first ding out of der Box & don for get it; yours Shurly Alex Fald

RAILWAY ENGINEERING AND MAINTENANCE OF WAY

Installation of Twenty-First Street Crossings, Chicago.

By A. M. Cornell, Ass't Engineer, C. & W. I.

The Chicago & Western Indiana Railroad completed last July the installation of an extensive and complicated set of crossing frogs with the Pittsburgh, Fort Wayne & Chicago Railway (Pennsylvania Railroad), the Illinois Central Railroad and the Chicago & Alton Railroad, at Twenty-first street and Stewart avenue, Chicago.

All the roads mentioned have operated their present number of tracks at this point for a number of years, but the location of the Pennsylvania tracks was changed in connection with its new double-track lift bridge over the South Branch of the Chicago river, just north of the crossings and west of its old swing bridge, necessitating new crossings for five tracks of the C. & W. I. Co., two of the C. & A. and two of the I. C.

The new alignment crosses within the limits of the old crossings of the I. C. and C. & W. I. and of the C. & A. and C. & W. I., making two groups of complex crossings, as shown in figures 2 and 3.

Group 1 is the intersection of two I. C. tracks with two Pennsylvania tracks and one C. & W. I. Group 2 is the intersection of the two Pennsylvania tracks with one C. & A. and one C. & W. I. track.

That an appreciation may be had of the installation difficulties, with reference to traffic conditions, it is interesting to know that these tracks are among the busiest in Chicago. Approximately 900 train movements are made over these crossings in a twenty-four hour day, and 75 in a single hour in the morning. A large proportion of the traffic is composed of the passenger trains of eleven roads to and from four of Chicago's six passenger stations.

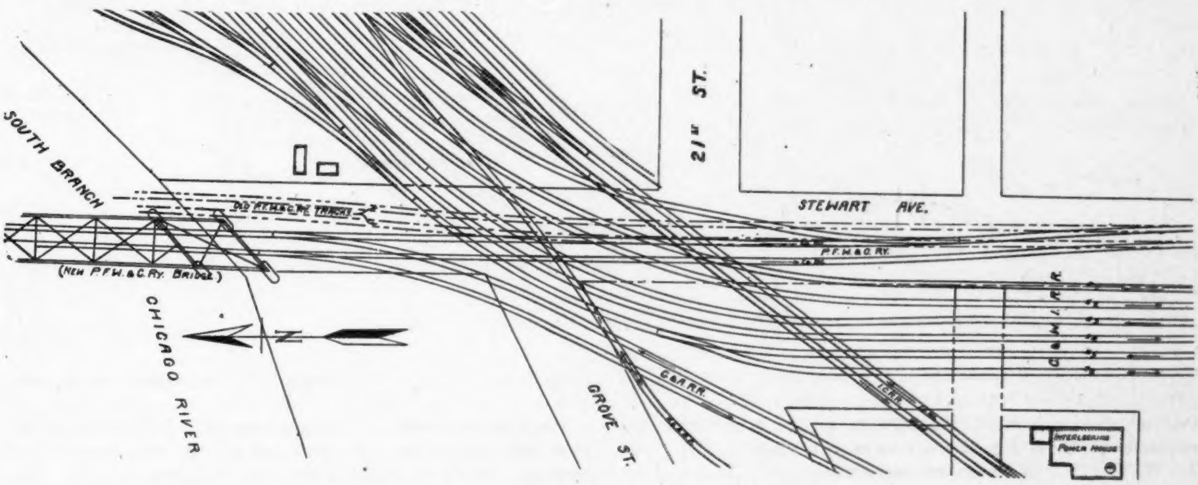


Fig. 1. Plan of Tracks and Crossings, 21st St., Chicago, C. & W. I. R. R.

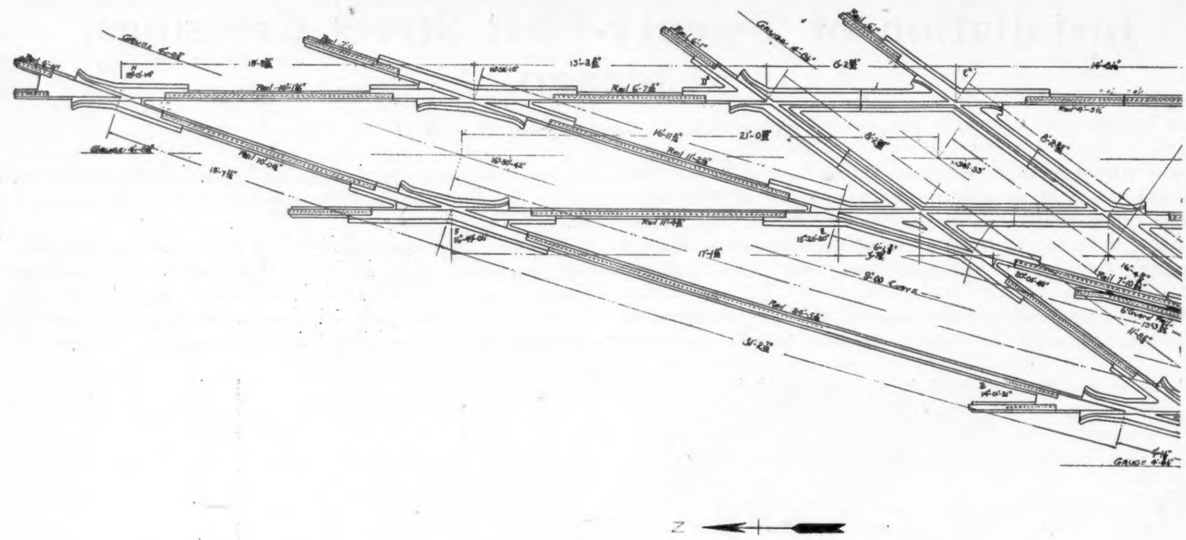
General View. Crossings at 21st St., Chicago, C. & W. I. R. R.

SURVEYS.

It was necessary, in the two groups of complex crossings, to have a sufficient distance between the intersection of any two gauge lines with the gauge line of the third track. In group No. 2 this condition obtained, resulting in a sufficient piece of metal at each of the five intersection triangles, a maximum width of metal of 11¼ inches and minimum of 7¾ inches. In group 1, however, the new alignment of the Pennsylvania tracks crossed the old position of the I. C. and C. & W. I., so as to make the gauge lines intersect so closely as to make the crossings impractical of construction. As the Pennsylvania and I. C. tracks are tangent and parallel, and the C. & W. I. track is on a curve, the latter was the logical track to shift. A 9 degree curve was projected through the length of the crossing on an alignment that gave the best average width at the seven intersection triangles. Five of these triangles were built solid, the maximum width of metal being 11¼ inches and minimum 4¼ inches. This adjustment changed the alignment of the C. & W. I. 475 feet, with a maximum shift of 2 feet 8 inches east in the southerly part, and 9 inches west in the northerly part. In order to have No. 1 and No. 2 C. & W. I. tracks not less than 13 feet centers it was necessary to compound the curve at the north end to 11 degrees, 30 minutes. South of the crossings the curvature was compounded to 6 degrees, 23 minutes, to run into the tangent.

The crossings of the two Pennsylvania tracks with C. & W. I. tracks No. 2, No. 4 and No. 5 offered no unusual features. These three C. & W. I. tracks were re-run to make as good alignment as possible, consistent with the present I. C. and C. & A. crossings, which were not disturbed.

In addition to the traffic condition described and the fact that no two of the five C. & W. I. curved tracks are concentric and



Group No. 1. Crossings, 21st St. and

that all are compounded, the difficulty of the field survey was increased by heavy fog at the time it was made.

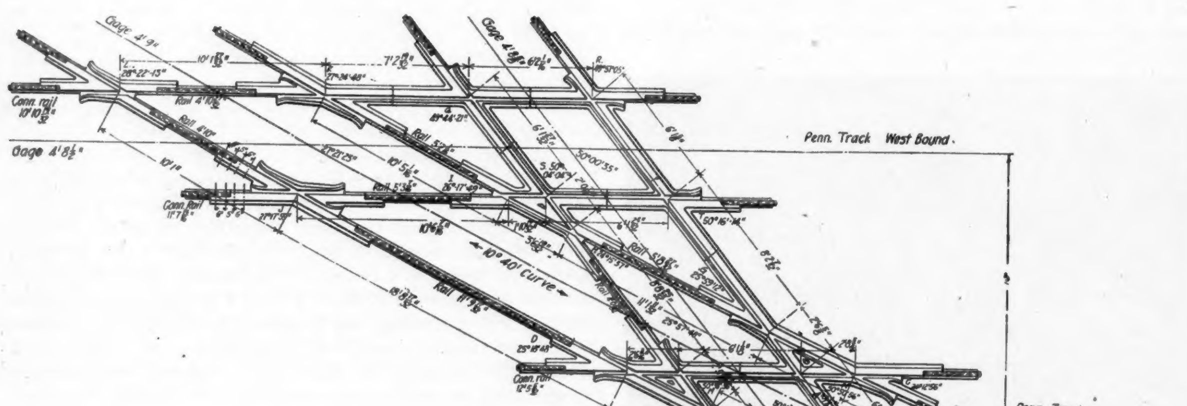
TYPE OF CROSSINGS.

Manganese crossings having been used to a considerable extent and with satisfactory results on the C. & W. I. for some years, that class of construction of the solid type was adopted, of weight to conform to 100 pounds A. R. A. type "A" rail, for three reasons:

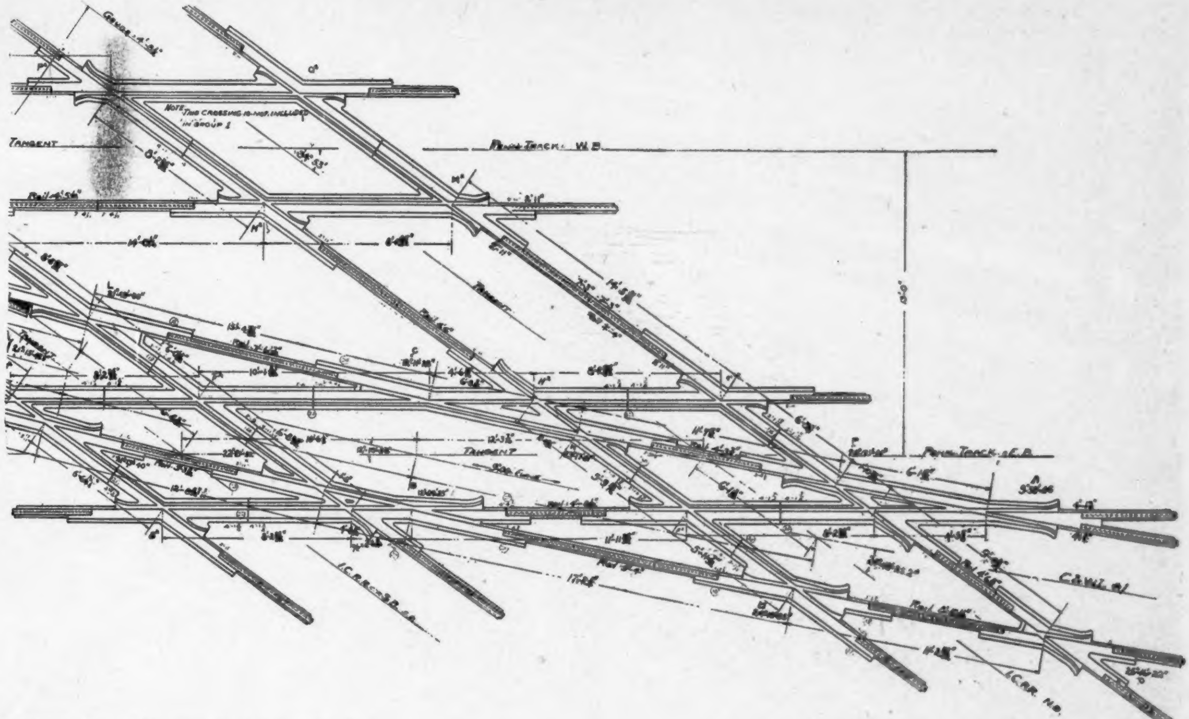
1. A built up type of "T" rail crossing would have been very difficult, if not impossible, to build in the complex groups 1 and 2.

2. Owing to the heavy and high class of traffic, and the various interests to be considered, the matter of maintenance and renewal is unusually important. In the type adopted all bolting and splices have been reduced to a minimum, the splices used being of the same type as the C. & W. I. standard for 100-pound rail. The various connections are such that renewal of any part can be made with hardly more labor than changing out a rail in an ordinary track.

3. As a matter of economy, the Manganese frogs should wear here approximately three times as long as a "T" rail crossing, thus saving the operating department from the frequent loss of busy tracks, for both installing new crossings and repairing old, also the expense of track labor, besides the increased cost, in the end, of the crossings themselves.



Group No. 2. 21st St. Crossings, Chicago, C. & W. I. R. R.



Stewart Ave., Chicago., C. & W. I. R. R.

Some of the features of design incorporated, if not original, are at least unusual. The base of the castings was made wide and solid, with the exception of such openings as are required to remove the cores. In addition to giving a stronger casting than the ordinary method in which the base is largely open, the particular advantage gained is that it eliminates the use of separate base plates, in providing a sufficient bearing surface on the ties.

CHANGE OF GRADE.

The tracks on the Pennsylvania Company's new bridge are 3 feet 9 inches higher than on the old bridge.

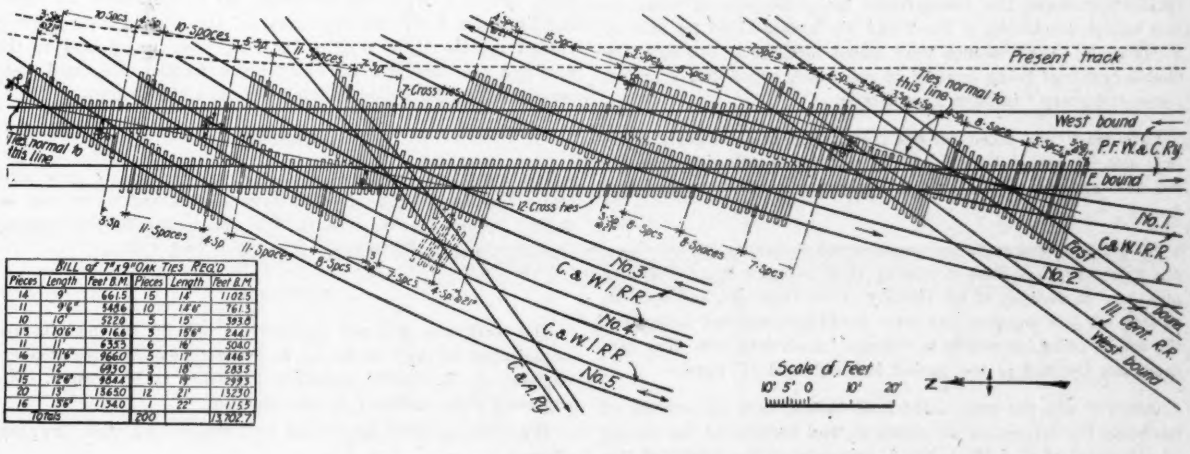
The approach to the bridge is over this set of crossings on a 1.5 per cent gradient, beginning at the I. C. tracks and requiring a maximum raise of 2 feet 4 inches at the northerly end of the layout, in C. & W. I. track No. 5. As the grades of the C. & W. I. and Pennsylvania are in a generally opposite direction, it was necessary to establish the gradients of the Pennsylvania tracks at different elevations, with the rails all in the same plane. The difference in elevation between the east and west bound Pennsylvania tracks was placed at what permitted the C. & W. I. tracks to cross at a level grade. This arrangement enabled bringing all the crossings to a good surface and uniform super-elevation for the C. & W. I. curved tracks, although slightly out of level for the Pennsylvania. The level grades of the C. & W. I. tracks through the crossings were carried south to the intersection with the existing ascending grade. To the north the new grade was made 1.4 per cent on tracks No. 2, No. 3 and No. 4, and 1.6 per cent on No. 5, which leads to the Eighteenth street freight yard.

The present grade on the C. & W. I. south of the I. C. crossings being 1.8 per cent, a flatter gradient was of no particular advantage for the new work.

One-hundred-foot vertical curves were put in at all changes of grade.

INSTALLATION.

It was necessary for the Pennsylvania to abandon its old eastbound track early in the construction of its new bridge. This made it possible to install the new crossings with no interference



BILL of 7"x9" OAK TIES REQ'D					
Pieces	Length	Feet B.M.	Pieces	Length	Feet B.M.
14	9'	661.5	15	14'	1102.5
11	9'6"	548.6	10	14'6"	761.3
10	10'	522.0	5	15'	393.8
13	10'6"	916.6	3	15'6"	244.1
11	11'	635.3	6	16'	504.0
16	11'6"	966.0	5	17'	446.3
11	12'	693.0	3	18'	283.5
15	12'6"	984.4	3	19'	299.3
20	13'	1365.0	12	21'	1323.0
16	13'6"	1134.0	1	22'	115.5
Totals			200		13,702.7

Tie Placing Plan and Bill of Material, 21st St. Crossing, C. & W. I. R. R.

View of Crossings Proper After Replacement, 21st St., Chicago, C. & W. I. R. R.

with Pennsylvania traffic. All raising of track was done on crushed stone ballast.

After the tracks were brought to the desired grade the crossing timber was placed according to the tie spacing plan. In tracks No. 4 and No. 5 the ties were placed under traffic, but to facilitate matters, the Pennsylvania being desirous of using its new bridge, tracks No. 1, No. 2 and No. 3 were killed for part of a day each. The crossings were bolted together to one side, the simple crossings being handled in one piece, group No. 2 in two pieces and group 1 in three, by a derrick.

Each track was killed for the installation of the simple crossings and for group 2 for from 2½ to 6 hours, allowing time for the final spacing of the ties, the necessary connections and surfacing.

No attempt was made for record speed in laying the crossings, but great care was used in placing them to exact line. This was necessary on account of the rigidity of the crossings, and because, as they all join together, any error would be continued throughout the set, it being impossible to "fudge" them into line. The care used was justified in the perfect line obtained all ways.

Group 1 was the most difficult to install, both on account of its being the largest set of crossings, and because of the change of alignment of C. & W. I. No. 1, necessitating the killing of this track until the entire set was placed. This group was handled in three pieces, the first including the north bound I. C., the second its south bound, so that the I. C. would lose only one of its two tracks at a time.

The actual point of the south frog in the east bound Pennsylvania and C. & W. I. was accurately set to the stakes, the crossing lined for I. C. and Pennsylvania, the alignment then being correct for the C. & W. I. The next piece was joined to the first and also lined for the two tangent tracks. The third piece was joined to the second and fell into its right position.

DRAINAGE.

The important matter of drainage was thoroughly gone into, and a complete system of catch basins, inlets and sewers was installed before any track work was done. Figure 4 shows the drainage layout with type of inlets and catch basins.

PERSONNEL.

The work was planned and carried out by the maintenance organization of the C. & W. I.: E. D. Swift, engineer maintenance of way; A. M. Cornell, assistant engineer; E. W. Powell, office engineer; John Mahoney, track supervisor.

The crossings were constructed by Pettibone-Mulliken Company, Chicago.

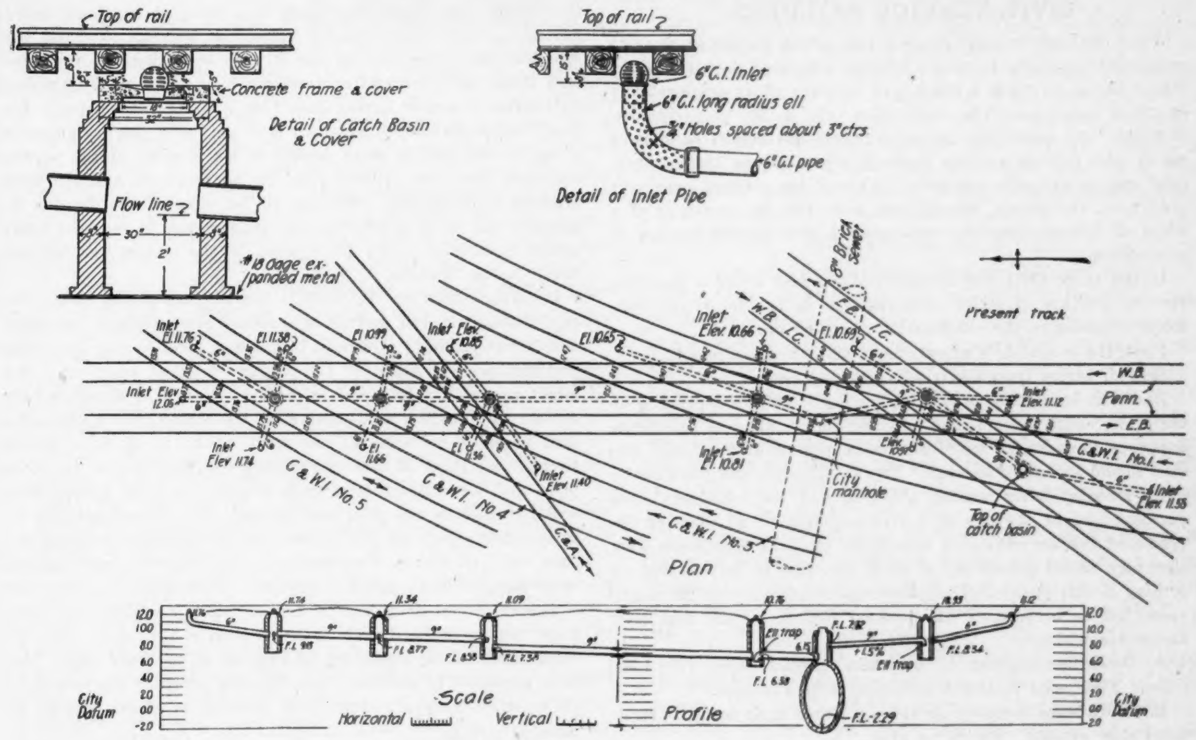
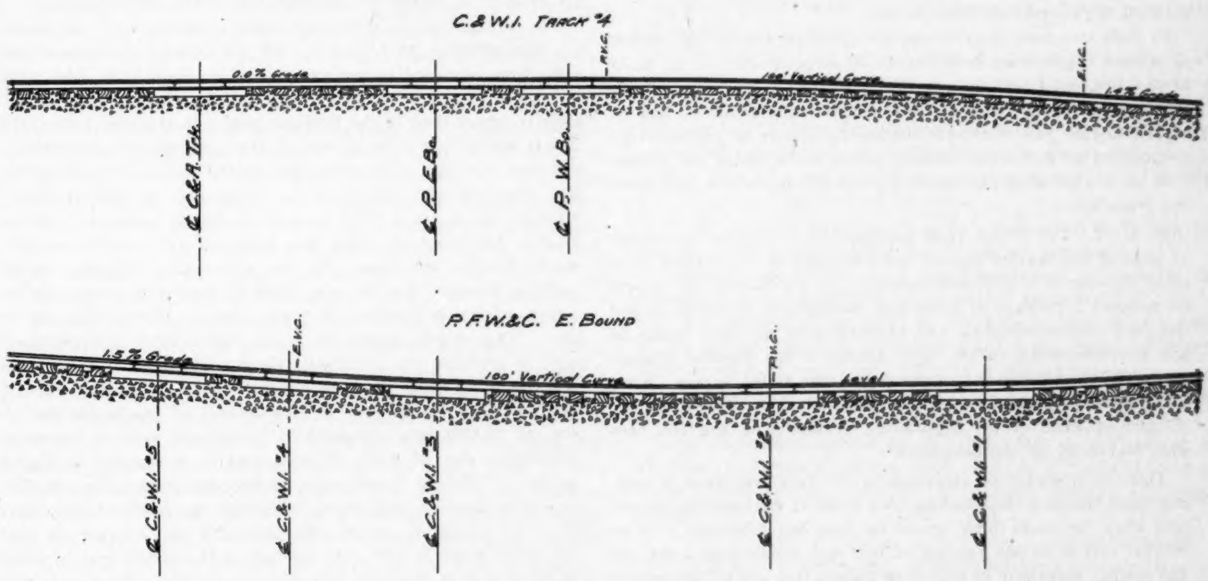


Fig. 5. Detail Drainage Plan and Section for Crossings, 21st St., Chicago, C. & W. I. R. R.

At the close of the fiscal year ending June 30, 1914, the Baltimore & Ohio Railroad System comprised 5,799.54 miles of main tracks owned, which with 2,903.76 miles of side tracks and yard tracks and the main line tracks, sidings and yard tracks leased and operated over by trackage rights, brings the grand total of all tracks operated up to 8,908.34 miles. This mileage embraces 4,487.22 miles of first main tracks, 1,275.78 miles of second main tracks, 177.10 miles of third main tracks and 41.97 miles of fourth main tracks. Since this compilation was made the Moorefield and Virginia railroad has been taken over, embracing 38 miles of line and bringing the total road mileage, as at present established, to 4,516.22 miles.

Six thousand bushels of lodgepole pine seed are being collected this fall on the Arapaho national forest, Colorado, for use in reforestation work next spring.

The Philippine bureau of forestry has recently invited bids for the cutting of nearly 300,000 acres of choice timber-land on the public forests on the island of Luzon.



Cross Section Parallel With C. & W. I. Tracks and at Right Angles, Showing Gradients and Vertical Curves.

CIVIL SERVICE FAILURES.

While civil service examinations for certain classes of work is an absolute necessity to obtain suitable help, it is doubtful if the system should be made a blanket of to cover all professional and executive positions. The application of it to properly discriminate and select high grade engineers has proved it to be a hit or miss process, and has made it a joke among trained technical men in executive positions. While it has selected some very good men, the general results look more like the workings of a wheel of fortune than the outcome of a systematized process of elimination.

In the U. S. Civil Service examinations held about a year ago for the position of senior civil engineer in the Interstate Commerce Commission the examination consisted of:

First, the candidate's narrations of his own achievements.

Second, letters from his friends praising him.

And that is all there was to it, success or failure depending on the praise of his friends, and how apt his narrative of experience happened to strike the examiners' estimation of what a really able man should have been through. Two things stuck out prominently —his friends' letter writing abilities, and the examiners' own personal idea of the life of a civil engineer. And some of the results of this are worthy of note to let the profession know what they may expect should any of them ever care to be classified according to this system. The following list are some of the actual cases, but on account of the personal feelings of the men their names are withheld:

A. Valuation engineer for a certain railroad system over 4,000 miles. Nine years with that company. Failed to pass.

B. With same company as above. Heads their corps of structural steel experts. Failed to pass.

C. Voucher clerk with same company as above. Passed. Received high mark.

Another case of "the first shall be last and the last shall be first," but the application of this Biblical saying to such an important thing as the Government Railroad Valuation Service is not only doubtful but asinine.

In the examinations for junior civil engineer for the same service, amongst many cases of almost ludicrous results we have the following:

E. E. B. But little education to start with; has been axman, chainman, rodman, transitman, resident engineer, etc.; failed in the subject of "Theory and practice of railroad surveying," but received 96 in mathematics.

J. R. W. An honor graduate University College, London, and a mathematical prize winner elsewhere; failed in mathematics, but received high marks on other topics.

In these two cases the civil service examiners reverse the verdict of several engineering departments of large roads. E. E. B. is always sent out to do the practical work in the field, while J. R. W. is kept in the office for his mathematical abilities, and in regard to this particular examination J. R. says he proved every proposition by a separate method before he let go of the papers.

In an examination for engineer Reclamation Service held some five years ago—

W. H. T. For fifteen years assistant U. S. engineer in charge of some of the heaviest harbor and river work in the country; also chief engineer of a 1,500-mile railroad. In his examination papers he enclosed a package of plans and photographs of works he had designed and constructed, and between some of these sheets he had slipped sealing wafers, easily broken if the slightest attempt was made to look into any of the pages. He failed to pass. When his papers were returned to him the seals were unbroken; the designs of some of his engineering achievements had not been even looked at by the examiners.

This can probably be explained by the fact that there is nothing more tiresome than looking over a lot of examination papers, and when the same thing has to be done day after day it is no wonder that a certain amount of bias and carelessness leaks into the system, especially in regard to papers that are looked over in the latter part of the day's work. In England, where civil service is a much older institution than it is here, it has been found advisable, with certain higher classes of papers, to have the examiner mark the hour of the day on each sheet he reads, so that those sheets read after a certain hour are subject to review by another examiner during some time in the forenoon, for it has been discovered that an examiner starting out at the beginning of a day's work will be more careful in his scrutiny of the papers, and that this care will relax as the hours go on and the work becomes more irksome, until toward the close of the day his inspection will be so indifferent and judgment so biased that many useful candidates would be rejected if the matter was left entirely to his decision.

It is high time our U. S. Civil Service Commission either discarded their wheel of fortune or examined some of their examiners, and it was probably a mistake in the first place to ever give them jurisdiction over some of the higher technical positions. One might as well try to ascertain the astuteness of a detective by a written examination as to determine the constructive ability of a civil engineer by what he can write about it, or by what his friends may think of him—his writing qualifications are too often poor, and the support of friends lacking; and the reverse when writing abilities are good and support of friends loyal, the inferior ability gets the job the same as in bare-faced politics, and thus the Civil Service Commission is unconsciously practicing the same thing it was created to prevent. That there is a need of a civil service system cannot be denied, and the individuals of the force can be credited with doing as well as they know how, yet there seems to be something lacking up at the head end. They have presumed to examine those who are probably above any list of questions they are capable of devising or understanding the answers thereto.

NEW SOUTH WALES GOVERNMENT RAILWAYS.

When commenting some time ago on the ups and downs of the State railways of Australia we referred to the large reduction in the net revenue which some of the systems experienced between the years ending in June, 1912 and 1913. The State of New South Wales was one of the sufferers, its railway surplus having fallen from 415,513*l.* for the year ending in June, 1912, to 186,904*l.* for the succeeding twelve months. The figures for last year, for which the report has recently been issued, show that the position has been maintained, with, indeed, a slight improvement, the surplus for the twelve months ending June, 1914, amounting to 209,367*l.* The year has seen considerable changes, both in earnings and expenses, and the small expansion of the net revenue is, under the circumstances, rather disappointing.

The earnings of the system increased in the year by just about 1 million sterling, to 7,742,241*l.*, but the working expenses at the same time increased by nearly 800,000*l.* to 5,409,820*l.*, and, with increased interest charges, the net result, as shown above, is only slightly better than in the previous year. In the report for 1913 it was shown that a large part of the expansion of the working expenses was due to increased wages and salaries. Part in the last year has been caused by a considerable increase in train-mileage, but again a large amount is due to wages and salary awards, the effect of which has been felt fully in this twelvemonth for the first time. No less a sum than 555,305*l.* in the working expenses for the year 1913-14 represents extra cost of wages, of which 253,036*l.* is purely due to increased scales of pay. The awards made, to which the railway commissioners have to conform, are continually placing additional burdens upon the system. During the year under review an additional sum of 144,578*l.* was due directly to new awards of wages boards. A sum of 18,439*l.* was disbursed in compliance with an industrial arbitration Act of 1912; 23,203*l.* went in promotions to higher grades; 37,594*l.* to classification advances to drivers, etc.; 21,870*l.* in merit advances, and so on. Recently the hours of duty have been the subject of review, with the result that though this year the effect is small, next year the cost to the system will be about 64,000*l.*, and in the year following to 130,000*l.* Next year also will be affected by awards made in connection with locomotive

laborers and iron-workers, while other claims are constantly coming forward.

In face of these increases it is not surprising that the State railways have had recourse to measures similar to those adopted elsewhere. Rates and fares have been increased on a scale which, it is estimated, should bring in additional revenue to the sum of 350,000*l.* A 10 per cent increase has been made on various classes of goods traffic rates. As regards passenger traffic, season-ticket rates have been raised 20 per cent, outer suburban fares 5 per cent, and cheap excursion fares and workmen's-ticket rates have both been advanced. The estimated sum of 350,000*l.* is about equally divided between goods and passenger traffic. These advances will probably do something to bring home to the public the inevitable effect of making constant concessions. The railways are public property, and awards made by the public authorities have to be met at the expense of the public. In part the beneficiaries have to contribute, directly or indirectly, to the sum required. The remainder is contributed by people who do not benefit. Much the same thing happens here, though the public usually flatters itself that the "companies" have to meet the bill. This they do, of course, either by passing the expense directly to their thousands of shareholders, or by transferring the burden to their patrons.

The increased train-mileage of about 1,465,000 miles on the figure for 1913, bringing the total, last year, to 20,549,695 train-miles, was due primarily to an all-round increase of traffic. The number of passengers traveling showed an increase of 7,000,000 on the year before, while the goods traffic increased by 1,579,592 tons. This was nearly all accounted for by increased intensity of traffic, the new lines opened during the year only totaling about 36½ miles. The number of miles open for traffic at the end of the last financial year (June, 1914) was 3,967½, but though the building programme is large, little appears to have been done recently in adding to the mileage, since attention has been concentrated on completing some of the duplications which are considered essential to a satisfactory service. New lines are constructed by the Public Works Department, and then handed over to the railways. We understand that new work was largely suspended in 1913-14, and the staff transferred to the Railways Department, by which it was employed last year on duplications equivalent to 49 miles of line completed, another 122 miles of duplications and deviations being in hand. These, for the most part, are on the lines converging on Sydney and Newcastle.

The programme of new work involves lengths of railway aggregating about 907 miles in hand, and a further 516 miles in prospect. The most important works in hand are the North Coast Railway, of which about 149 miles remained to be opened at the close of the financial year, and a line from Dubbo to Werris Creek, 157½ miles in length. The latter is a cross-country line, running roughly northeast and almost parallel to the coast, from Dubbo, which is 283 miles from Sydney on the western system, to Werris Creek on the northern system, a few miles less from Sydney. This line will be crossed by another line now in progress from Dunedoo, 239 miles from Sydney on the northwestern system. The first 76 miles of this line is in hand, but it is planned ultimately to push it right on to Burren Junction, on the northern system, and 403 miles from Sydney. Another line of considerable length in hand is that from Wagga to Tumberumba, a distance of 76 miles, stretching towards the Victoria border and the Murray river, into a district hitherto poorly served. One of the most interesting lines in hand, or perhaps by now completed, is that from Finley to Tocumwal, which has been called for for long years past. Other lines are extensions of existing branches, in many cases opening up districts far inland. We have frequently pointed out that much of the New South Wales railway traffic is long-distance traffic, and as time goes on the distances will tend to become longer. This is clearly evident from figures in the various yearly reports. For instance, the report for 1903 showed the average mileage per ton of grain, flour, etc., to up-country stations was 177.47 miles; today the corresponding figure is 252.57 miles. In the case of wool, the average distance per ton used in 1903 to be 243.76 miles; today it is 304.13 miles. Live stock has not increased its distance to quite the same extent, but instead of 243.76 miles, the average is now 251.16, and so on. Of course, not all the development is proceeding in the back blocks. Changes have come over some of the earlier settled districts, which have resulted in more traffic, but of an altered character, so that the increase does not always show up in figures. The general tendency, however, is very evident.—*Engineering.*

VERTICAL CURVES.

R. H. Hallsted, Assistant Engineer, Missouri Pacific.

The practice of designating vertical curves by the rate of change per station is exceedingly convenient; however, the writer has not seen in any of the field books a demonstration of the manner of working out vertical curves starting with the rate of change per station. The field books assume the length of the curve, and thus make every curve a special problem to which a general table can not be supplied. No originality is claimed for the following methods, but they are given in the belief that they will be of benefit to those who have followed the usual and more cumbersome methods given in the field books.

Among those who follow the practice of calculating vertical curves by the rate of change per station, a curve having a rate of change of 0.1 ft. per 100 ft. station, is spoken of as a one-tenth curve; a curve having a rate of change of 0.2 ft. per 100 ft. station as a two-tenths curve, and so on.

The Manual of the American Railway Engineering Association contains the following recommendation in regard to vertical curves: "The length will be determined by the gradients to be connected. On first-class lines a rate of change of 0.1 per station on summits and 0.05 in sags should not be exceeded. On minor lines 0.2 per station on summits and 0.1 per station in sags may be used."

It is not the purpose of this article to treat of the principles underlying the selection of the proper curve, but it may be said that even a short vertical curve is of material benefit in improving the riding qualities of track. The writer has in mind a busy main line with numerous sags where the gradient changes as much as 1.8% and where 0.2 vertical curves have been used with apparently successful results; and it would seem that the recommendation of the association represents a high standard.

Such a curve as referred to above is a parabola, as is the case with the curve demonstrated in the field books, one definition of a parabola being that it is a curve which changes its direction an uniform amount per unit of length. Consequently the following properties of this curve may be demonstrated by the application of the laws of the parabola:

1. The length of the vertical curve is equal to the algebraic difference of the grades (expressed as per cents in the usual manner) divided by the rate of change per station.

Example:—A descending (minus) grade of 0.8% intersecting an ascending (plus) grade of 0.6% gives an algebraic difference of 1.4%. If a 0.2 curve is to be used, its length will be 1.4 divided by 0.2, giving 7 stations, or 700 ft.

2. The ordinate from the grade line to the first station on the vertical curve is one-half the rate of change per station.

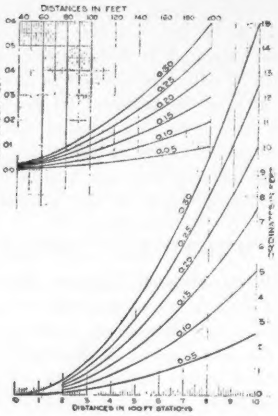
Example:—At 100 ft. from the beginning of a 0.2 curve the distance from the grade line to the vertical curve is 0.1 ft.

3. The ordinate at any point on the curve is equal to the square of the distance from the beginning of the curve (expressed in stations) multiplied by one-half the rate of change per station.

4. The ordinates for any vertical curve may be obtained by preparing a table of "second differences."

Example:—Based on 0.05 curve. (Note that the ordinate at 10 ft. from the beginning of the curve would be $0.1^2 \times 0.025$, or one-tenth station, squared, multiplied by one-half the rate of change per station.)

Station.	Ordinate.	First Difference.	Second Difference (Constant).
0+10	0.00	....	....
0+10	0.00025	0.00025	0.00050



Ordinate Table for Vertical Curves.

0+20	0.00100	0.00075	0.00050
0+30	0.00225	0.00125	0.00050
0+40	0.00400	0.00175	0.00050
0+50	0.00625	0.00225	0.00050
0+60	0.00900	0.00275	0.00050
0+70	0.01225	0.00325	0.00050
0+80	0.01600	0.00375	0.00050
0+90	0.02025	0.00425	0.00050
1+00	0.02500	0.00475	0.00050
1+20	0.03600	0.00525	0.00050

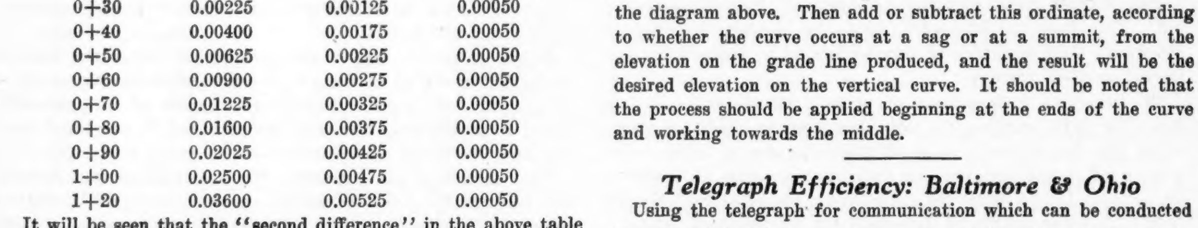
It will be seen that the "second difference" in the above table is one one-hundredth of the rate of change per station. The table is prepared by working from right to left, adding the second difference to the first difference and then adding the sum to the preceding ordinate. This method eliminates the many multiplications involved in the field book method.

The benefit of having the table worked out for each 10 ft. is that stakes may be set readily at even stations when the curve begins at a "plus;" or that stakes may be set at bridge ends or other points not occurring at a regular station. If considerable accuracy is desired, corrections for plusses, not falling at an even ten feet, may be obtained by interpolation.

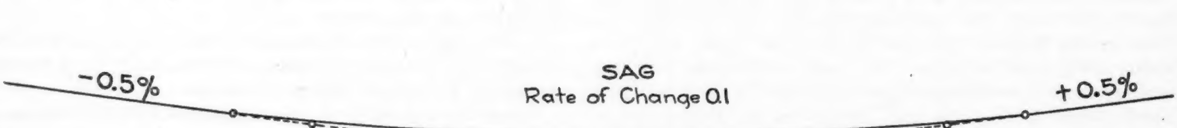
The above table should be carried on out to embrace the longest curve which is likely to be met with in practice. It is necessary to go through this process only once, for it will be noted that the ordinate for a 0.1 curve will be twice the corresponding ordinate for a 0.05 curve; the ordinate for a 0.15 curve will be three times the corresponding ordinate for a 0.05 curve, and so on. This follows from Rule 3 given above. To avoid all calculation whatever of ordinates, the following diagram is given. The abscissae in this diagram represent distances along the center line, and the ordinates represent the distances from the grade line to the vertical curve. The curves plotted in the low portion and right-hand side of diagram give ordinates from zero to station 10. However, the curves converge at zero and the ordinates at the left of the sheet are hard to read and curves giving ordinates from 0+40 to 2+00 are given in the curves plotted at the top of the sheet on a larger scale. (The ordinates from 0+00 to 0+40 are negligible for the rates of change covered by this diagram.)

The following sketch gives a graphic illustration of the application of the above table, although, of course, in practice it is not necessary to draw a sketch to work out the problem:

The vertical curve will extend in all cases an equal distance each way from the intersection of the grade lines. The first thing to do is to figure the elevations on the grade lines produced, as shown in the first line of figures in the sketch. Under each elevation set down the ordinate for that point taken from the proper curve in the diagram above. Then add or subtract this ordinate, according to whether the curve occurs at a sag or at a summit, from the elevation on the grade line produced, and the result will be the desired elevation on the vertical curve. It should be noted that the process should be applied beginning at the ends of the curve and working towards the middle.



Elev. grade line produced	95.00	96.00	97.00	98.00	99.00	100.00	100.00	100.00	100.00	100.00	100.00
Correction	0.0	0.05	0.20	0.45	0.80	1.25	0.80	0.45	0.20	0.05	0.00
Elevation on curve	95.00	95.95	96.80	97.55	98.20	98.75	99.20	99.55	99.80	99.95	100.00



Elev. grade line produced	102.50	102.0	101.50	101.00	100.50	100.00	100.50	101.00	101.50	102.00	102.50
Correction	0.00	0.05	0.20	0.45	0.80	1.25	0.80	0.45	0.20	0.05	0.00
Elevation on curve	102.50	102.05	101.70	101.45	101.30	101.25	101.30	101.45	101.70	102.05	102.50

Graphic Illustration of Application of Ordinate Table.

Telegraph Efficiency: Baltimore & Ohio

Using the telegraph for communication which can be conducted by mail is being discouraged amongst officials and employees of the Baltimore & Ohio Railroad in an effort towards greater efficiency.

The Baltimore & Ohio Railroad is urging its employees in this class of service to obtain ample rest while off duty, so they will be in proper condition for the safe, prompt, and efficient performance of their work.

On a railroad system the size of the Baltimore & Ohio, where fully 30,000 messages, varying from two words to one thousand words in length, are handled each day, the importance of being brief is clearly seen. As a substitute for the telegraph the railroad has adopted a mailgram service for quick communication in the transaction of its business between departments, messages of this character being handled by train service and with great dispatch.

CONCRETE  DEPARTMENT

Does the Use of Several Different Concrete Mixtures in a Structure Pay?

In many concrete structures such as bridges and buildings several different grades or mixtures are used to economize on cement. This may be entirely justifiable in so far as strength required is concerned and may fulfil all theoretical requirements, but often the saving is of a more or less imaginary character, for the contractor will in general make a good allowance for the usual difficulties to be encountered in using several different grades of concrete in one structure.

In the ordinary reinforced concrete bridge the cost of the cement is in reality only a small portion of the entire cost, and changes in mixtures result in an almost infinitesimal economy. For example, in the new 1,350-foot reinforced concrete bridge of ribbed-arch spans over the Schuylkill River at Reading, Pa., the cost of the cement was only 8.5 per cent of the contract price and only 4.5 per cent of the total cost of the structure, including real estate and property damages. When the cement cost is such a small item of the entire cost it is evident that no saving worthy of much consideration can be made by changing mixtures in different parts of the structure.

It sometimes occurs that different grades of concrete from that used in the main body of the structure are necessary for exposed faces to allow the desired architectural treatment and surface finish, and the cost of this concrete is always greatly increased because of the difficulties attendant with placing. In cases where the exposed surface area is great as compared with the total yardage of concrete, economy can be effected by using the same mixture throughout.

Then again, where several grades of concrete are used some errors in placing are sure to occur unless the inspection is constant and the very best. The tendency in such cases is, almost without exception, if an error is made, to place the weaker mixture in portions requiring the better mixture for structural reasons, and under some conditions this may invite failure. If the different mixtures are used in such parts of the structure as are built at different times the danger of error in placing is practically eliminated, thus justifying to some extent, for example, the use of a leaner mixture in plain concrete footings than in the network above.

Where the use of two different kinds of coarse aggregate is necessary to produce the desired finish, as in the case of the outer pilasters of piers of the Fallsway Viaduct, described on another page, the procedure may be entirely justified by the difference in cost of coarse aggregate, in this particular case gravel and stone, but where cement alone is the main factor in changing the mixture the economy is slight and often offset by cost of placing. Richer concrete will result in stronger, more durable and more nearly waterproof structures at a surprisingly small additional expenditure, which in the main will be justified in the end.

Permeability of Concrete

The results of the tests of the permeability of concrete of different kinds and mixtures now being made at the University of Wisconsin will, when completed, form a most valuable contribution to engineering knowledge regarding the water resisting properties of concrete. The abstract of a paper by Prof. Morton O. Withey, under whose direction the tests are being made, appearing on another page, is only a progress report on a small part of the contemplated tests, but the conclusions drawn are of very great importance and are an indication of the value of the undertaking from an engineering standpoint.

The statements lately advanced by individuals and technical societies that under ordinary conditions waterproof concrete can be obtained without the use of special waterproofing, provided proper precautions are taken, are borne out by the conclusions drawn by Prof. Withey.

Especially significant are the statements that "Through increasing the fineness of the cement a reduction in the rate of flow and a considerable increase in the strength of a 1:9 mix were secured," and that "By grading the sand and gravel in accordance with Fuller's curve it was possible to obtain practically watertight concrete of 1:9 proportions under pressures of less than 40 lb. per sq. in. To secure such results, however, *requires great care and careful supervision in mixing, in determining the proper consistency, in placing and in curing the concrete,*" and that "The use of the proper amount of water necessary to produce a medium or mushy consistency is one of the most important conditions in securing impervious concrete, especially when lean mixtures are used."

In other words, care exercised in selecting materials and the operations of concreting can be justly charged to waterproofing, for this is the result of such extra work. The use of most waterproofing materials and compounds requires the same amount of care to insure good results, and perhaps in many cases the careful supervision and mixing has contributed more to the success of waterproofing than the compound itself. However, in many cases waterproofing compounds and materials are necessary to insure good results, for the methods cited above are not adaptable to all conditions. This means that the selection of any particular method of waterproofing should be made only after a most careful study of conditions and requirements. In this work the engineer will be aided greatly by the *Masonry Report* of the A. R. E. A. of 1914, published on pages 182 to 186 of the April 1914 issue of *Railway Engineering*, which is without doubt the best treatment of the subject of waterproofing at the disposal of the engineer.

It should also be noted that the curing is of the utmost importance in the making of impervious concrete, premature drying, destroying the imperviousness of 1:9 mixes, and seriously impairs that of the 1:2:4 mixtures.

If it is desired to make waterproof concrete without the use of foreign materials, record runs, various labor-saving distributing devices, the man at the mixer and the materials themselves require the most careful consideration, for any one or all of these factors may contribute to disaster.

The city of Butler, Pa., will construct a viaduct on Wayne St. over the tracks of the B. & O. R. R. and the B. & L. E. R. R. The viaduct will be about 1,060 ft. long and 50 ft. wide. The estimated quantities of materials are 875 tons of structural steel and 2,800 cu. yds. of concrete.

Construction Features—Fallsway Viaduct, Baltimore, Md.

Description of the Viaduct and of a Very Large Gravity Spouting System for Concrete Distribution on a Long Viaduct Which Involved the Use of Towers 200 Feet High.

GENERAL.

The Fallsway viaduct, Baltimore, Md., now under construction, is a reinforced concrete structure about 1100 feet long and 75 feet wide with an earth fill approach between retaining walls at the south end, making the structures about 1500 feet long overall.

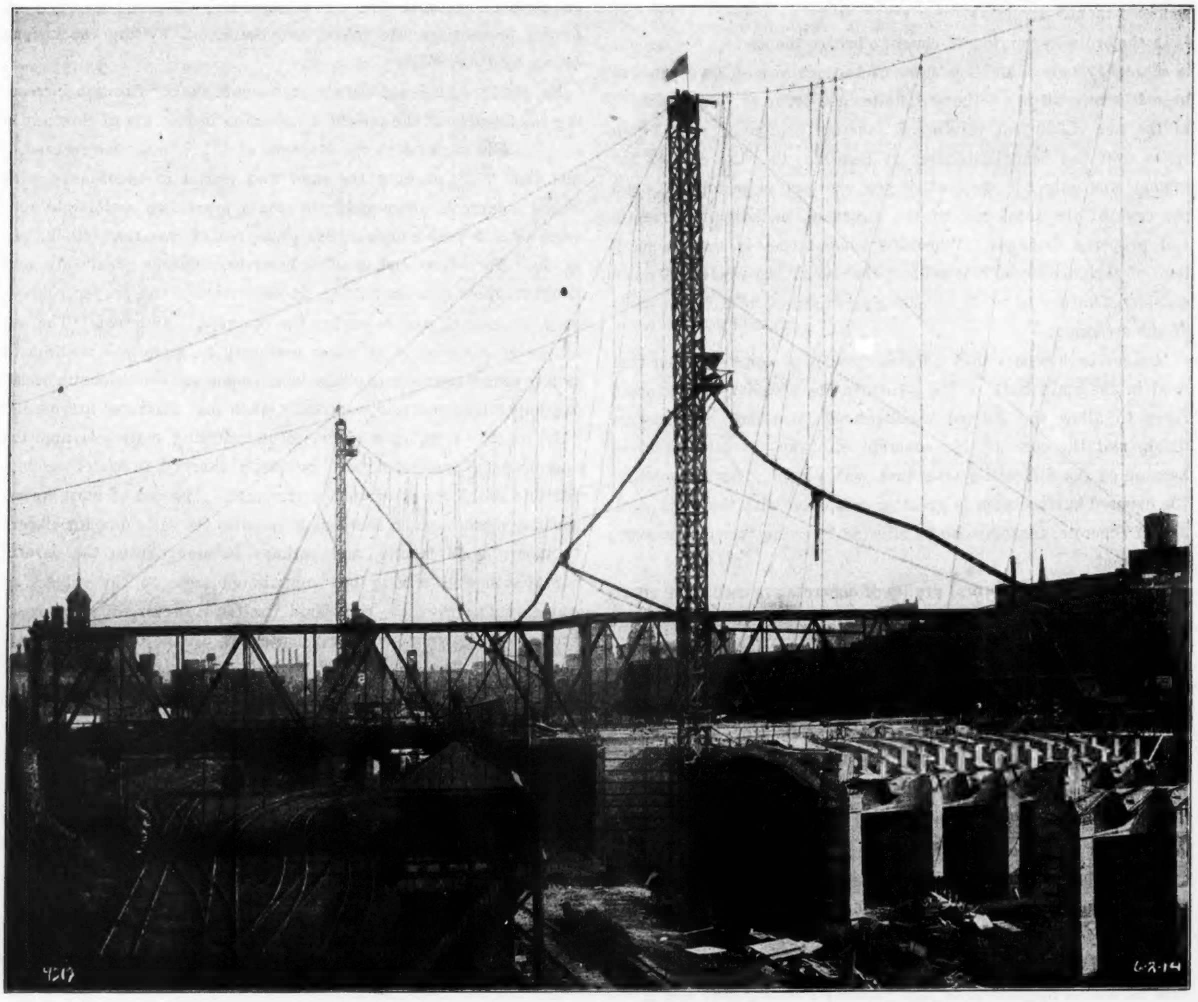


Fig. 1. Complete Concrete Distributing System—Following Viaduct, Baltimore, Md. Type of Viaduct Construction Shown in Foreground.

The viaduct creating a new street, extends from Madison street to Biddle street on an average grade of 3 per cent, and is built directly over the Jones Falls conduits, from which it derives its name. The Pennsylvania Railroad tracks not only pass under the viaduct, but flank it on either side south of Eager street and on the east side north of Eager street, while the houses fronting on Guilford avenue run back to the viaduct on the west.

The bridge proper consists of 17 arch spans, 64 feet center to center, carrying a reinforced concrete deck. Each arch span consists of nine arch ribs, five of which are carried concrete piers and the intermediate ribs rest on transverse girders between piers. (See Figs. 1 and 2.) The floor slab is carried on transverse beams resting on the arch ribs at the crown and on columns built up from ribs at the ends and over transverse girders. The concrete conduit upon which the three intermediate piers rest and the foundations for the outer piers were built under another contract. (See Fig. 2.)

DETAILS OF DESIGN.

The viaduct is designed for heavy city loading. The concrete used was of a 1:2:4 mixture, crushed stone being used as coarse aggregate for all exterior or showing faces which are to be dressed, while gravel was used for all concealed work.

The piers for each span are of skeleton construction made up of five pillars, 10 feet long and from 2½ to 3 feet wide, connected at the top at a point 18 feet above the top of conduit cover, by a transverse girder 3 feet wide by 6½ feet deep, reinforced with 1¼-inch straight and bent bars. These piers are spaced 64-foot centers, while the individual pillars are spaced 19-foot 1-inch centers for outer pillars and 18-foot 9-inch centers for the intermediate ones.

The pillars extend to the top of girders where skewbacks for

arch ribs are formed with bars projecting to lap with arch rib reinforcement. Skewbacks for the four intermediate arch ribs are formed at the same time as transverse girders are built. These skewbacks project the same distance from girder as those on piers, thus allowing the use of the same size of centering for all ribs. Fig. 1 shows this construction very clearly.

The arch ribs are circular segmental with a rise of 7 feet and

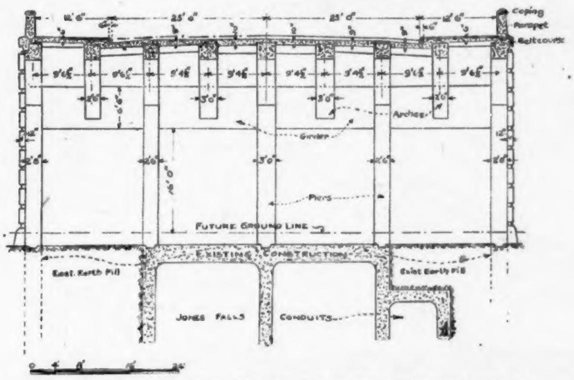


Fig. 2. Cross Section Showing Details of Construction.

a depth of 2 feet 6 inches at crown and 3 feet 6 inches at the haunches. The three middle arch ribs are 3 feet wide, the next two on either side 2 feet 6 inches wide and the outer ones 2 feet 8 inches wide, the three outer ribs being 9-foot 6½-inch centers and the others 9-foot 4½-inch centers. The three intermediate arches are reinforced with four 1-inch square bars in extrados and intrados 3 inches from face, while the other arches have three instead of four bars in each plane. From quarter points to springing two extra bars are placed.

Pockets are provided in ribs at crown for transverse floor beams and at ends of spans three rows of reinforced columns carry the beams. The roadway slab is 10 inches thick over middle arches and 9 inches thick at sides, while the sidewalk slab is 6 inches thick with a slope to the gutter. The roadway slab is heavily reinforced with every third bar bent up over floor beams, as shown in Fig. 3. Expansion joints are provided over each pier and also

Fig. 3. Deck Reinforcement, Fallsway Viaduct.

between the solid spandrel over outer arches and piers to allow the free rise and fall of arches.

The outer pillars of piers are ornamented with quoins projecting 12 inches beyond main face of pillar. The spandrel wall is capped with a molded belt course surmounted by a solid concrete handrail or parapet.

CONSTRUCTION REQUIREMENTS.

The construction of the viaduct because of various features of design was divided into nine different operations, stated briefly as follows:

(1) The piers were poured up to the bottom of the transverse girders carrying the arch rings. It was intended that the girders and piers were to be poured at the same time, this method had to be abandoned since all the grout ran into the piers and left the gravel in the girder. This method would also have further complicated the work by the fact that the outside piers were built of stone concrete to be bush-hammered, while gravel concrete was used in the intermediate piers and transverse girders.

(2) The transverse girder, intermediate skewbacks to receive the four arch ribs framing into the girder, and the piers up to the top of girder were next poured. On the outer portion of the outer piers a wire screen was placed about 1 foot from the forms and the space between this and forms was filled by hand with stone concrete; this allowed the use of gravel for all the rest of these sections.

(3) The outside piers were then poured up to the bottom of the belt course.

(4) The arch ribs and columns on which the floor beams rest were next concreted.

(5) The transverse floor beams over the girder were placed. This was necessary, since an expansion joint was required in the floor slab over each transverse pier girder and the beam directly

Fig. 4. Main Distributing Tower, Material Bins in Foreground.

over the girder had to be poured first in order that the floor slab might slide over it.

(6) Floor slab and other transverse beams under roadway were then concreted.

(7) The sidewalk slab and beams were next placed.

(8) The belt course on each side concreted, and

(9) The parapet walls on both sides completed the concreting operations. In this latter wall fine stone was used and since there was no division for this material in the storage bins, a small mixer which was moved along the floor slab was used to mix the concrete.

From the above it can be seen that a very flexible method of placing concrete was an absolute necessity. For this reason several methods were considered, but the gravity spouting apparatus was finally adopted, since it was found to be the most flexible, cheapest, and to require less room than any of the other systems considered.

DESCRIPTION OF MAIN CONCRETE PLANT.

Eager street is carried across the old bed of Jones' Falls on an old stone arch about 30 feet above the roof of the conduits through which the Falls now flows. The mixing plant was placed

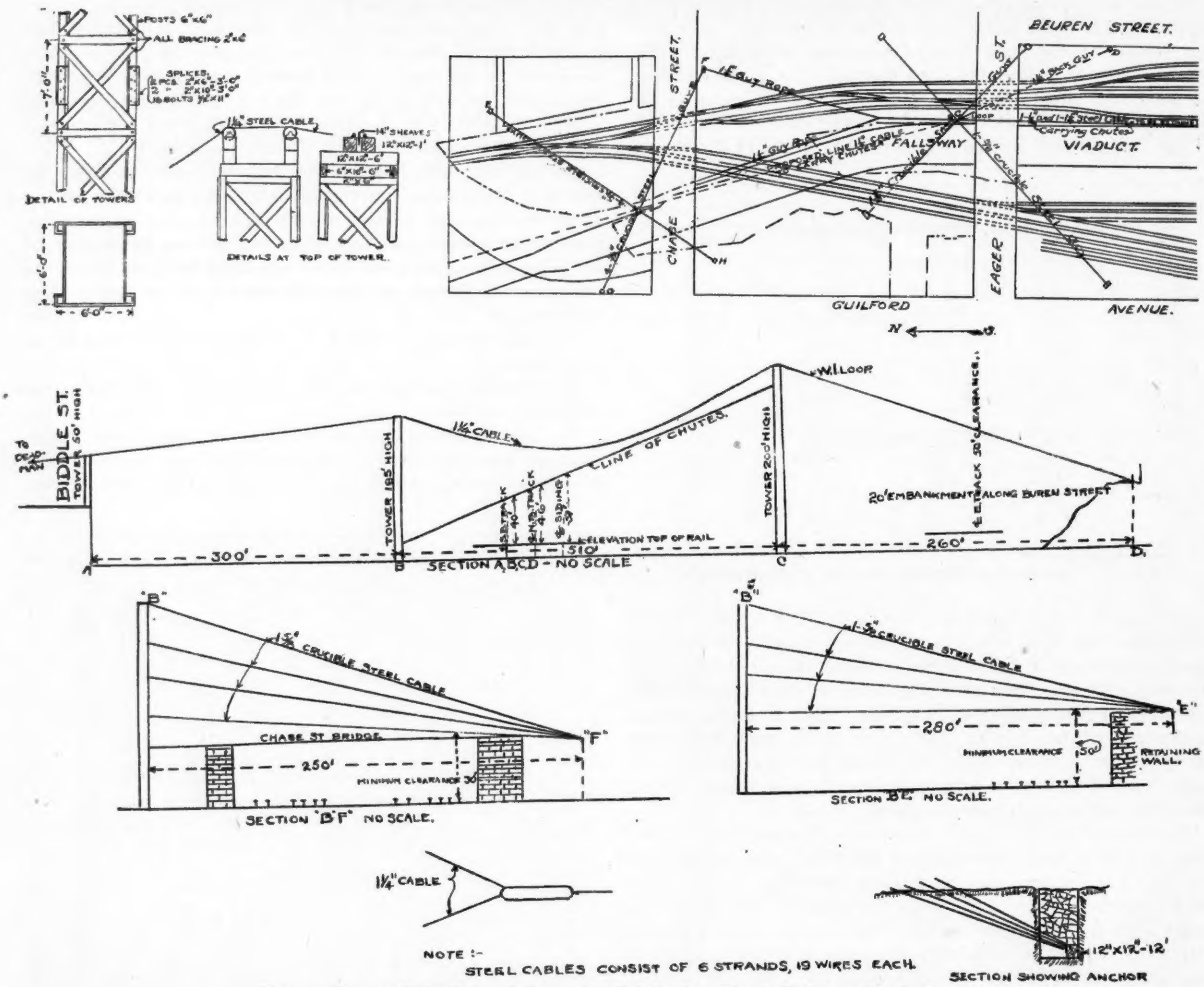


Fig. 5. Plan and Sections of Concrete Distributing Plant, Fallsway Viaduct.

on the north side of this old arch, the top being about three feet above the grade of the street. The sand and gravel is hauled to the bins from the dock in auto trucks and dumped into the several partitions. The stone, shipped to the site by rail, is dumped into a pit and elevated to its bins by a bucket elevator. The gravel bin holds about 100 cubic yards, the sand bin about 50 cubic yards, and the stone bin about 50 cubic yards. The sides of bins are formed of 1-inch boards with 2x4 studs every 18 inches and 6x6 horizontal rangers about 5 feet apart vertically. The rangers are held together by old cables (⅞-inch galvanized guy line) twisted together. The floor which slopes to the center on about a 35-degree angle is made of 2-inch plank with 1-inch plank laid in the opposite direction, lengthwise with slope of bin. The posts and rafters are 10x10's. The angle of slope of bin bottoms was not made greater because there was not sufficient headroom. The cement is wheeled by hand from the cement house to the mixer, a distance of about 40 feet. A two-bag Foote mixer receives the material from the measuring box and dumps the mixed concrete directly into the elevating bucket of ½ cubic yard capacity, in which it is elevated to the top of the 205-foot distributing tower and automatically dumped into a receiving hopper which feeds the chute. The hoist and mixer are operated by steam engines supplied with steam from two boilers to insure continuous operation.

The main tower, 205 feet high by 6 feet square, was erected at Eager street alongside the mixing plant. (See Fig. 4.)

A 1¼-inch crucible cast steel cable was strung from this tower south to a tail tower 50 feet high and 550 feet away, directly over the east side of the viaduct. On account of the railroad tracks it was not possible to get an anchorage which would be in a straight line with the two towers, and a "Y" was therefore put in the main cable about 150 feet north of the Eager street tower. Two anchorages were then built so that each leg of the "Y" would make an equal angle with the main cable, so that there would be no unequal strain or side pull on the tower. Two 14-inch sheaves, one on the south side and one on the north side of the tower, support the cable. This allows slack to work from one side of the tower to the other and also makes an easy bend in the cable at the point where the stress is greatest. (See detail Fig. 5.)

The tower was built with 6x6 legs, 2x6 braces with a horizontal brace every 7 feet. The legs were 14 feet long, making a splice every other story. The splice was a simple butt joint with 2-inch scabs on the four sides. Bolts ½-inch diameter were used for all splices and also for bracing. This tower was built entirely of Virginia pine, but the legs were so badly warped and checked that the difference in the cost between this and Georgia would have been saved in erection had the latter been used. The tower was erected by means of a gin pole so constructed as to slide between the two 4x4-inch vertical bucket guide, the gin pole being raised into the last completed section of tower as the work progressed, thus allowing it to easily handle the timbers for the next section. Four sets of four ⅝-inch crucible cast steel guys support the tower, and in addition it was necessary on this tower to put a back guy at the top as it tended to lean toward the load. (See Fig. 5.)

Four hundred and fifty feet of Insley 10-inch three-quarter round chutes were hung on this cable with four line gates and

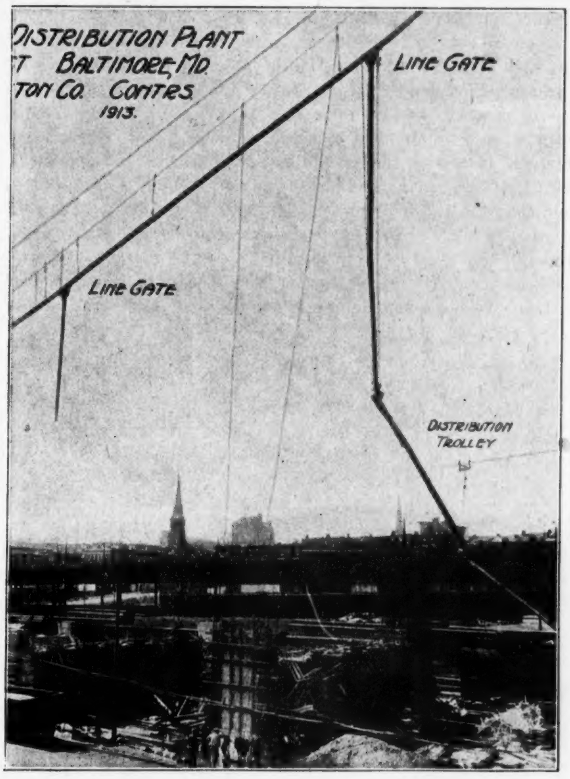


Fig. 6. Line Gates and Distributing Chutes on Main Shaft.

vertical down spouts. (Fig. 6.) A line gate is a section with a trapdoor in it which can be opened or shut to allow concrete to be taken off at this point or to continue down the main line at will. Two small towers were erected along the center line of the viaduct, one opposite the tall tower and one on Eager street, and a ¾-inch cable suspended from them, parallel to the main cable, about 50 feet from it horizontally, but only about 40 feet above the top of the work. A 50-foot trussed spout was hung from the main cable and this auxiliary line, into which the down chutes discharged the concrete. From it the concrete ran into another chute with hopper end and swivel head. This last chute was supported on the hopper end by the auxiliary line, while the other end rested on the forms, and by swinging this chute around about 50 feet in all directions could be covered. Open, continuous line chutes 30 feet long were used throughout, except at line gates and where it was necessary to use shorter ones to bring the line gates to the desired point.

All the chutes were erected from the lower end, and as a chute was gotten to the desired elevation it was pulled ahead. For this purpose a kind of trolley was designed, with a sheave running on the main cable and an eye-bolt at the bottom, from which the block and fall hung. A clamp was placed on the top of this trolley and a ½-inch wire rope was fastened to this. This rope ran over the top of the tower and down to a hoisting engine which was used to raise the elevator bucket. The chutes were suspended from the main cable by ¾-inch Manila rope running through a double and single block, and the free end was tied on the ground. As the chutes were raised to approximately the desired elevation the rope was tied so as to hold them at this level while they were being pulled up to the tower, and the extra rope (the length necessary to reach to the ground) was coiled up on the chutes. After all were strung and pulled up to the tower a man went over the line throwing down this extra length of rope and loosening the knots. The chutes were then lined up and the free ends tied. Whenever adjustment was necessary to maintain the grade of 1 foot vertical drop to 3 feet horizontal, it was very easy to raise or lower the chutes by means of this rope as desired. It is very important to keep an even grade because the concrete will pile up if the lower chute is on a flatter grade than the one above it. This is natural, as the rate of flow is slower in the second chute and the concrete is delivered to it faster than it can run away.

It was impossible to pour the portion of the viaduct north of Chase street with the chutes from the main tower at Eager street, and a tower 185 feet high was built just north of Chase street at a distance of 520 feet from the main tower. This secondary tower is of the same construction as the main tower and guyed with four lines of guys composed of four ⅝-inch crucible steel cables, as shown in Fig. 5. The concrete is mixed at the Eager street plant, hoisted to the top of the tower and then chuted a distance of 520 feet to the auxiliary tower, where it is collected and re-elevated and run to the point desired, either north or south of Chase street by a line of chutes on each side of the tower. Fig. 1 shows the entire plant with the auxiliary tower in the foreground.

Insley buckets, hoppers and chutes were used throughout and have proven very satisfactory. They have been in use over a year and showed no apparent signs of wear after placing about 10,000 cubic yards of concrete. The quality of concrete delivered was excellent and has been very favorably commented on by both the engineers in charge and visiting engineers. Concrete has been dropped as high as 100 feet through the vertical down chutes without any separation of the aggregate. The only explanation of this is that it seems to follow the sides and makes its way down in a series of spirals instead of falling freely. A total of 180 cubic yards of concrete in nine hours is the record run, but the mixer and the elevator bucket were not large enough to keep the chutes working at anything like their full capacity. On an average 30 seconds were required to raise the bucket to the top of the high tower, 5 seconds to dump the bucket, and 10 seconds to drop the bucket. About 20 seconds were required to dump the mixer, making a round trip in a minute and five seconds on the average, while the quickest round trip was 45 seconds.

TRAVELING PLANT FOR RETAINING WALL WORK.

The approach at the south end, about 350 feet long, consists of an earth fill retained by buttressed walls of reinforced concrete. To concrete these walls a traveling mixing plant with 40-foot

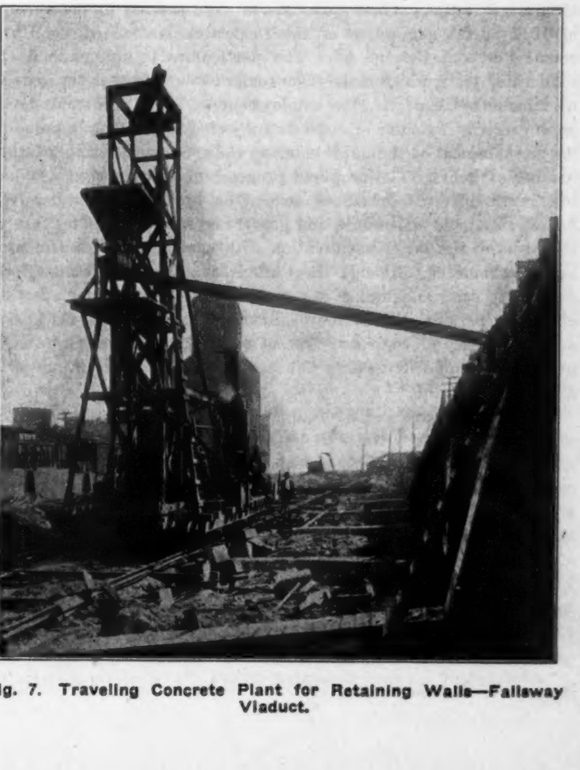


Fig. 7. Traveling Concrete Plant for Retaining Walls—Fallsway Viaduct.

tower, operating on a temporary track, was used. This plant, shown in Fig. 7, is 14 feet wide and 20 feet long, consisting of a mixer, hoisting engine, boiler and distributing tower mounted on a four-wheeled truck. The concrete was hoisted to the top of tower, discharged in the hopper and conveyed by a 25-foot section of chute to the forms at either side of the track. The materials were delivered to the mixer in wheelbarrows from piles dumped along the track and the cement from a storehouse nearby.

ARCH RIB CENTERING.

The forms of 2-inch lagging for each arch rib were supported on two wooden trusses built in halves with a depth of 3 to 4 feet and panel lengths of about 4 feet with 12 panels per truss. The upper chord timbers are 2x10-inch lumber cut to the curve of arch ribs, the lower chords are made up of 2x6-inch material and the diagonals of 2x6-inch lumber. All joints were fastened with ⅞-inch bolts. After the ribs were poured the forms for deck construction were erected on the projecting lagging of arch rib forms.

QUANTITIES AND COST.

The viaduct upon which active construction work began about Sept. 1, 1913, is now practically complete, will require a total yardage of concrete of 14,000 cubic yards and 800 tons of reinforcing steel. The estimated cost of the structure is $196,000, while the contract price for broken stone concrete was $9.25 per cubic yard and for gravel concrete $8.90 per cubic yard.

PERSONNEL.

The work is being done by Claiborne-Johnston Company for the city of Baltimore. Calvin W. Hendrick, consulting engineer, designed the viaduct and has charge of the construction. C. K. Allen is the engineer in charge. We are indebted to Mr. Elliott Vandevanter, chief engineer of Claiborne-Johnston Company, and Mr. Henry T. Peirce, who furnished the spouting equipment for photographs and data used in this article.

PERMEABILITY TESTS ON GRAVEL CONCRETE.*

By Morton O. Withey, Ass't Prof. Mechanics, University of Wisconsin.

This paper is a partial report on tests which are being conducted at the University of Wisconsin to determine the permeability of concrete to water. These experiments were started in the spring of 1912 at the suggestion of the Inspection Bureau of the Universal Portland Cement Co. The particulars in the method of conducting tests, which make them somewhat unique, are the use of machine-mixed concrete, the employment of large specimens having a prescribed volume of concrete subjected to water pressure and the measurement of the water entering the specimens during a large number of hours. The proposed program of experiments includes tests with different brands of cement on broken stone and sand, broken stone and screenings, and gravel and sand aggregates. Only the tests on the latter combination with one brand of cement are herein considered, although the work is now being done on mixes containing sand and broken stone. The reported tests include the effects on permeability of the following variables: Age, thickness and consistency of concrete; time of mixing; gradation of the aggregate; wet and dry sand; fineness of cement; and curing conditions.

Forms of Specimens—Several forms of specimens were experimented upon before the *PU* type shown in Figs. 1 and 2 was adopted. In molding these test-pieces, both mortar, shell and concrete core were cast at the same time. It will be noted that the area of the core in these specimens is one square foot, consequently the leakages read were in terms of this unit of area. This type of specimen was found very satisfactory for most of the tests made. These specimens when subjected to very rapid drying in curing in some cases cracked circumferentially in the plane of the lower edge of the castings. Moreover, it was impossible, with this form of test-piece, to determine the permeability of concrete with the pressure applied perpendicular to direction of pouring.

To secure some information regarding the effect of direction of flow with respect to the direction of pouring, two other types of specimens, *PUL* and *PUHC* in Fig. 1, were also tested. The *PUL* type of specimen has the same area of concrete exposed to water pressure and to air, but apparently the shrinkage strains encountered in casting render it difficult to secure sound specimens. The *PUHC* specimens have the advantage of being much easier to mold than the *PUL* specimens. In the former, however, the area exposed to water pressure is considerably less than that exposed to air.

Making and Curing Specimens.—The specimens were made of machine-mixed concrete in special molds, and in general two or

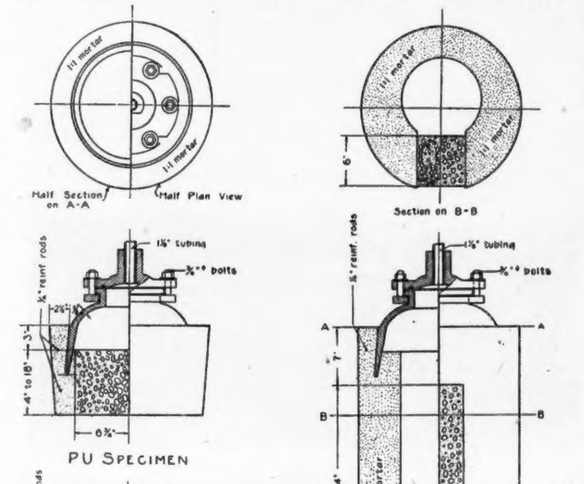


Fig. 1. Types of Permeability Test Specimens.

three compression cylinders 6 in. in diameter and 18 in. long were generally made with each batch of concrete.

On the day following the pouring the tops of the *PU* specimens and the outside surfaces of all others were chipped and scrubbed to remove lattance and rich mortar. In general *PU* specimens remained in the molds two days. Molds were removed from *PUL* and *PUHC* specimens after one day and the outsides of the test pieces covered with wet sacks. The interior surfaces of the concrete on *PUL* specimens were chipped when the specimens were two to five days old. The interiors of some of the *PUHC* specimens were chipped during the second week after making, while others were chipped after four or five days.

Normally, the interiors of all specimens were filled with water and the sack coverings kept wet by sprinkling every morning and night excepting Sunday, when they were sprinkled once only. The compression cylinders were in general treated the same as corresponding permeability specimens.

Testing.—Before testing, the specimens were washed out, placed beneath the permeability tubes and filled with water. In testing

* Abstract of a paper presented before the Western Society of Engineers, September 14, 1914.

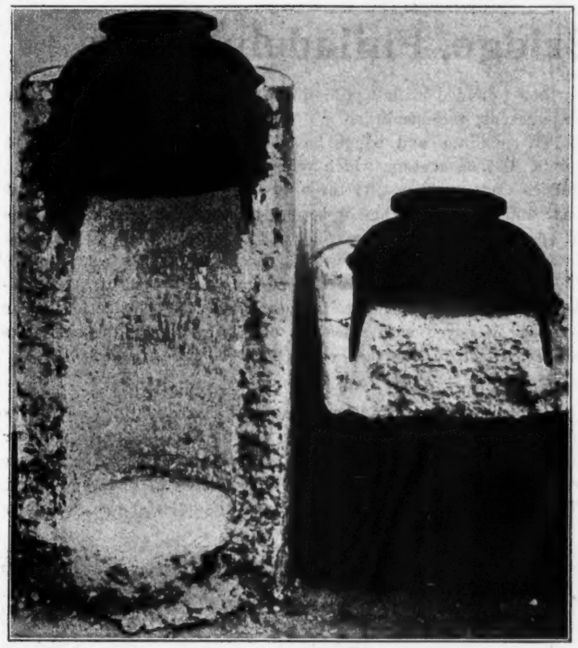


Fig. 2. Permeability Test Specimens of the PUHC and PU Types.

some of the *PU* specimens 5 lb. of damp Janesville sand was spread over the interior of each specimen before filling to serve as a filter. No sand filter was used on the *PUL* and *PUHC* specimens. After the gaskets had been inserted in grooves in the flanges and the castings had been bolted to the apparatus, city water was forced into the tubes attached to specimens until they were nearly full; air pressure was then admitted and the height of water in tubes read from time to time. Readings were taken in terms of 0.001 gallon and 1¼ cu. in. Ordinarily readings were taken at first, ½ hour after the pressure was admitted, then in perhaps one or two hours, and twice a day thereafter. From time to time observations were also made upon the appearance of bottoms of the specimens. In so far as possible, speciments were run for a period of fifty hours or more at approximately constant pressure. Most of the specimens were tested at one age and under one pressure.

Summary.

From these tests the following conclusions applicable to concrete made of like materials may be drawn.

1. None of the concretes tested were *absolutely* watertight if we consider flow into the specimen as proof of permeability, but the majority of the mixes were so impervious that no visible evidence of flow appeared. For most purposes such mixes can be considered watertight.

2. The visibility of dampness on the bottom of the specimens increased with the humidity of the air and the non-homogeneity of the concrete. The minimum rate of flow for which leakage was indicated was 0.00011 gallon per square foot per hour.

3. In tests of nearly all of the properly made mixes of 1:7 proportions, or richer, the rate of flow for a fifty-hour period was less than 0.0001 gallon per square foot per hour under a pressure of 40 lbs. per sq. in.

4. Through increasing the fineness of the cement a reduction in the rate of flow and a considerable increase in the strength of a 1:9 mix were secured.

5. By grading the sand and gravel in accordance with Fuller's curve it was possible to obtain practically watertight concrete of 1:9 proportions under pressures less than 40 lbs. per sq. in. To secure such results, however, requires great care and careful supervision in mixing, in determining the proper consistency, in placing, and *in curing* the concrete.

6. In the proportioning of such materials as these, volumetric analysis coupled with a determination of the density and air voids yields very valuable information concerning the best proportions of sand and gravel for a given proportion of cement. If proportions must be selected arbitrarily a 1:1½:3 mix, by volume, is very impervious. It should be remembered, however, that the volume changes in rich mixtures due to alternate wetting and drying are much greater than for lean mixtures. Consequently due attention must be given to the provision of expansion joints and reinforcement in structures made of them.

7. The use of the proper amount of water necessary to produce a medium or mushy consistency is one of the most important conditions in securing impervious concrete, especially when lean mixtures are used. Dry mixtures cannot be sufficiently compacted in the molds and are more difficult to cure properly than the mushy mixtures. Although the use of a wet consistency does not materially affect the imperviousness of very rich mixes, such as 1:1½:3, it greatly increases the flow through a lean mix.

8. For lean mixes made from damp sand it seems advisable to mix longer than is now common practice. These tests would indicate that for a mixer running at 30 r. p. m., a period of one and one-half to two minutes is required to secure thorough mixing of a 1:9 concrete. For a rich 1:1½:3 mix a one-minute period appears to be sufficient. The method of mixing in which water is first admitted to the mixer is to be condemned. A preliminary period of dry mixing lasting from 15 to 30 seconds seems desirable.

9. No stage or process in the making of impervious concrete is of more importance than curing. The results of these tests clearly demonstrate that premature drying destroys the imperviousness of 1:9 mixes, seriously impairs that of the 1:2:4 mixes and somewhat diminishes that of the 1:1½:3 mixes. For thin sections, not over six or eight inches thick, the curing conditions should be such that a lean concrete will be kept damp for a period of one month and a rich concrete for at least two weeks. Even after a month of proper curing, complete desiccation of a lean mix composed of these materials produces an increase in permeability, but the effect on a rich mix is not marked.

10. In these tests the imperviousness of the concrete increased rapidly with the age of the specimens for the first month; thereafter the change was not marked.

11. From the tests thus far made it seems probable that the permeability of lean concrete in a direction normal to the pouring is greater than in the direction of pouring.

THE RELATION OF POROSITY TO DISINTEGRATION IN CONCRETE.

Among the various tests made during 1913 in the Laboratory of the Board of Water Supply, New York City, were those made on porous concrete to forecast the effect of waters of the Catskill aqueduct city shafts on the strength concrete. These tests made by allowing city water to percolate through the porous concrete for one year. According to the 1913 report of the board, the strength was reduced to a small fraction of the normal strength.

Other tests showed that if a small quantity of magnesium sulphate or sodium sulphate was added to the water, the decomposing action on the concrete was greatly accelerated. Whenever acid was present the destruction was hastened, the rapidity of disintegration depending upon the nature of the acid solution.

The report states that "Impermeability is the quality of concrete which more than any other is conducive to durability under all conditions, and indications are that an ample proportion of cement is the most expedient means of attaining impermeability. The aggregates should be well balanced and the mixing of concrete thoroughly done."

One-half of the main line of the Canadian Pacific between Fort William and Vancouver is now double tracked. Chief Engineer Sullivan states that 350 miles of double track have been completed this year between Brandon and the Pacific coast. Prior to this year the road had double track between Fort William and Brandon, a distance of 559 miles, so that there now is a total of 909 miles. The distance between Fort William and Vancouver is 1,908 miles.

The City Avenue Arch Bridge, Philadelphia, Pa.

The city of Philadelphia is noted for its beautiful concrete bridges and the excellent methods of surface finish which have been developed by years of experience. The structure herein described and illustrated, although a highway bridge, presents such notable features in architectural treatment as to make it worthy of the attention of bridge engineers engaged in track elevation work. The curved connection between the wing walls and spandrel walls of bridge, the projecting pilasters at abutments separating the wings from the arch and the simple but artistic handrail give the structure a most graceful and impressive appearance.

The bridge, spanning a small stream known as Indian Run, was constructed under joint contract by the city of Philadelphia and the county of Montgomery, Pa., the center of the street which is carried over the bridge being the boundary line between city and county.

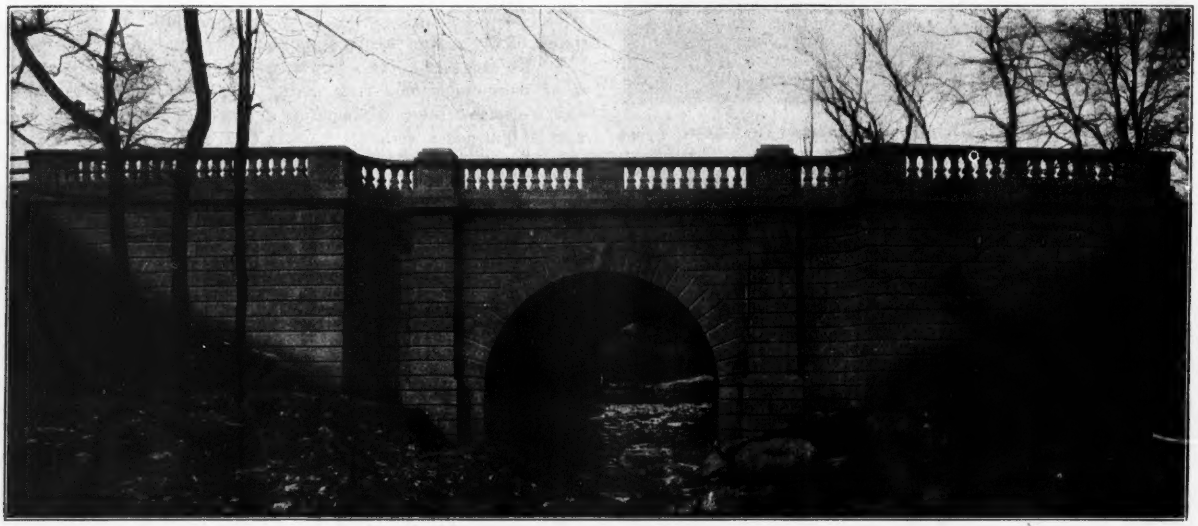
DETAILS OF DESIGN.

The arch ring is semi-circular with a clear span of 20 feet, a crown thickness of 2 feet 2 inches and a thickness of 4 feet 3 inches at the springing line. The springing line is 5 feet above the ordinary flow line and the abutments carried down 6 feet below the latter line are 6 feet thick. The arch barrel is 70 feet in length, while the width over wing walls is 80 feet. This narrowing of the roadway over the arch proper is accomplished by connecting the wing walls and spandrels by a concave curved section of wall which greatly enhances the beauty of the bridge.

The arch ring is of plain concrete of a 1:2½:5 mixture, with trap rock as the coarse aggregate and flat-slabs of one-man stone imbedded in the concrete as closely as possible. These stones were carefully set by hand in the wet concrete with their beds normal to the pressure line of the arch. The concreting of arch ring was done in five longitudinal sections of 35 cubic yards each from haunch to haunch in as many days. The faces of arch ring are marked to give the appearance of ring and keystones by V-shaped grooves. The abutments of 1:3:6 concrete are founded on solid rock.

The spandrel and wing walls are of the gravity section without reinforcement. The spandrel walls, which are completely separated from the adjoining wing walls by a vertical joint lined with a sheet of asbestos felt, were poured after the arch centers had been removed. The joint mentioned was used in order to prevent unsightly stains and cracks on surface of walls due to temperature movements of the arch ring and walls, and was therefore carefully waterproofed by the membrane method on the back and further provided with a tile drain to carry away any possible seepage past the membrane.

The spandrels and wings have V-shaped, horizontal, coursing joints, 16-inch centers, which relieve the monotony of the plain, dull concrete surface. At the abutments pilasters 4 feet wide at base and 3 feet 6 inches at coping project 9 inches beyond face of spandrels. These are carried up to the coping line and capped by a paneled block of concrete 3 feet wide and 4 feet 3 inches high. These pilasters form a very important part of the architectural treatment, as can be seen from the illustration. The roadway is paved with macadam on earth fill and the sidewalks are of granolithic-surfaced concrete on a cinder sub-base.



City Avenue Arch Bridge, Philadelphia, Pa.

HAND RAIL AND SURFACE FINISH.

The concrete balustrade and handrail, 3 feet 6 inches high, is composed of premoulded balusters set in a cast-in-place baluster and handrail. The balusters, each reinforced with a ¾-inch square rod, were cast in iron moulds, scrubbed and cured in the stream. The balusters were then set in place on the baluster rest, a hole in the bottom of the balusters engaging a lug cast on the rest. The handrails, reinforced with two ¾-inch bars, were then poured, securing the balusters at the top. The handrails mitre into the top of concrete posts over abutments and pilasters, and a sufficient number of joints are provided to prevent any random cracks caused by the wide range of temperature changes to which the handrails are subjected.

The showing faces are faced with a trap rock grit, crushed to pass a ⅜-inch and be retained on a ¼-inch sieve and mixed to the proportions of 1:1½:3 and applied to a thickness of not less than 1 inch against the oiled forms. This was immediately backed up with concrete and bonded in with large stones which bed in the main body of concrete and project into the facing. After 24 hours the forms were removed and the mortar scrubbed with brushes and a light hose stream of water to expose the aggregate.

COST AND PERSONNEL.

The cost of the bridge was $21,300, or $2.18 per square foot of area included between the ends of wings. The general design was prepared by Mr. John H. Dager, engineer of the Montgomery County Commissioners, and the detail plans were prepared and the construction supervised by the Bridge Division of the Bureau of Surveys, Mr. George S. Webster, chief engineer, and Mr. Jonathan Jones, assistant engineer, to whom we are indebted for photograph and data used herein. Mr. Patrick J. Lawler was the general contractor for the work.

REINFORCED CONCRETE FENCE POSTS, B. R. & P. RY.

The Buffalo, Rochester & Pittsburgh Railway uses concrete fence posts for line fences in various localities along its lines where the ordinary wooden posts are not adaptable, as at places where there is danger of destruction by fire.

The line posts are ordinarily spaced 16 ft. 6 in. centers and are of the tapered T-section type, with a length of 8 ft. These posts have a flnge 6½ in. in width and 1½ in. thick at the bottom, with a stem 6½ in. deep and 2½ in. thick at the butt, tapering to 2½ in. depth at the top, with a thickness of 1½ in., as shown in Fig. 1. The flange also tapers toward the top, where it is only 4½ in. wide and 1 in. thick.

The reinforcement consists of three ¼-in. diameter bars 7 ft. 6 in. long in each corner. Gravel concrete composed of one part cement and three parts of fine gravel is used in making all posts. The posts are poured in molds in a central yard and after curing are loaded on cars and transported wherever needed. The weight of these posts is 87½ lbs. each.

The posts are set into the ground for a depth of 3 ft. and the horizontal wires of the woven wire fences are fastened to them by means of No. 7 soft steel tie wires wrapped around posts and the ends twisted around the horizontal wires. Each horizontal wire is fastened at each alternate post.

At corners three special corner posts are placed in each line, at 7 ft. 6 in. centers, thoroughly braced and tied with concrete braces and wire ties, as shown in Fig. 1. Corner posts are made 6 in. square and 8 ft. long, reinforced with four ¼-in. diameter rods 7 ft.

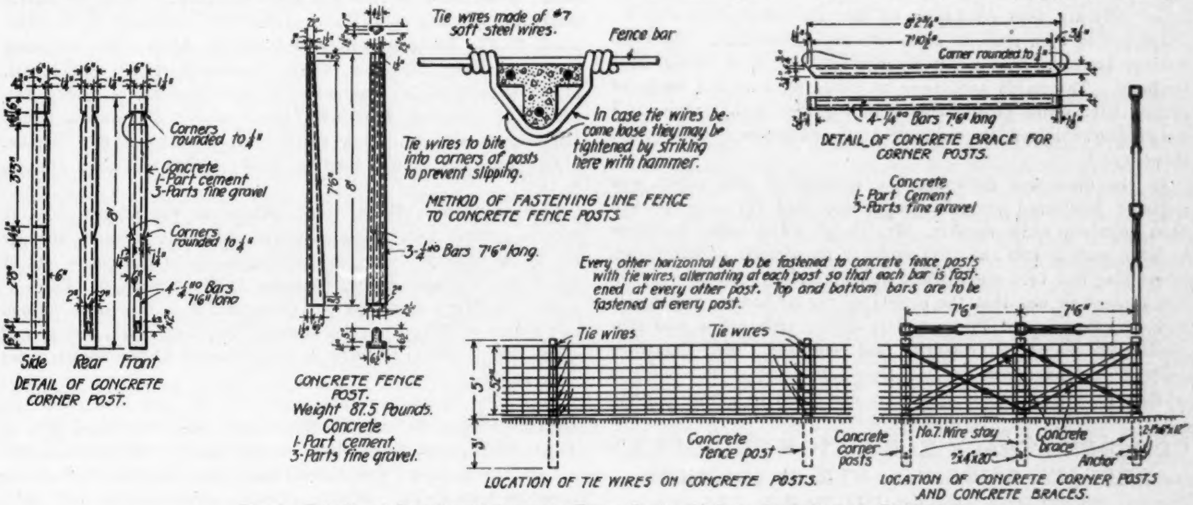


Fig. 1. Details of Reinforced Concrete Fence Posts, Buffalo, Rochester & Pittsburgh.

6 in. long, one in each corner. Concrete of a 1:3 mixture, using fine gravel, is used for the posts, and all corners are rounded off to a ¼-in. radius. Notches 1¼ in. deep are provided at the top and near ground line, to act as seats for the diagonal concrete corner braces. At the bottom is a slot 4 in. by 2 in. extending through the posts, into which short anchor bars are placed at right angles to fence line. These corner braces are 8 ft. 2¾ in. long and 4 in. square, with wedge-shaped ends to fit the notches in corner posts. The braces are reinforced and finished the same as the corner posts.

We are indebted to Mr. E. F. Robinson, chief engineer, Buffalo, Rochester & Pittsburgh Railway, for plans and data used in this article.

BLAST-FURNACE SLAG AS AGGREGATE IN CONCRETE.

A paper presenting some interesting results of an investigation to determine the value of blast furnace slag as aggregate in concrete was given at the 17th annual meeting of the Am. Soc. for Test. Mat. by W. A. Aiken, Vice-pres. H. S. Spackman Engraving Company.

Preliminary tests were first undertaken to develop the relative value of this material compared with limestone and Birdsboro trap rock, in order to determine whether or not a more extended investigation of furnace slag was warranted; the tests being carried on only to the 28-da. period. As a result of these early tests and the showing made therein by slag, an extended series of tests was undertaken. This involved the manufacture of 500 6-in. cubes of 1:2:4 cement-gravel-slag mixture (the sand not being what could be considered first-class material); 100 of these to be crushed at each of the several periods, 28 das., 3 mos., 6 mos., 9 mos., and 1 yr., so as to arrive at entirely reliable averages, and to establish the uniformity of the character of the concrete. As the work progressed, the results were such that the number of cubes tested at the 9-mo. and the 1-yr. period was reduced to 50 each, and it is proposed to crush the remaining 100 cubes at 6-mo. intervals up to 6 yrs.—10 cubes at each period.

Compressive tests furnished the following average data for slag concrete, the average weight of which was 140.8 lbs. per cu. ft.:

Age.	Compressive Strength Lbs. per Sq. In.
28 das.	1,561
9 mos.	2,841
1 yr.	2,797
3 mos.	1,952
6 mos.	2,589

These figures are interpreted by Mr. Aiken as follows:

The main point is whether or not the compressive strength values herein developed are sufficiently great to warrant the use of slag as aggregate, in competition with broken stone and gravel. We think that the findings are in favor of this, since experience has proven that the crushing strength of broken stone or gravel concrete, made up under ordinary field conditions, will not average over 1,500 lbs. per sq. ft. at the age of 30 das.

Consequently, from the actual strength of the concrete developed in these tests, its weight per cu. ft. (which is less than that of most materials used similarly); the recognized solubility of slag, which permits it to act as a puzzolanic material; its alkaline nature, which is especially conducive to rust-prevention in the case of reinforced concrete construction; and from the relatively high combined percentages of silica, alumina and iron, which make for permanency of the resulting concrete; it must be concluded that slag of similar constitution is in every way satisfactory for use as aggregate in concrete.

A standard Lehigh Valley Portland cement, normal in every respect, and Jersey gravel, material almost universally used as sand in the vicinity of Philadelphia, and crushed slag, commercially called ¾-in. material, were used throughout this investiga-

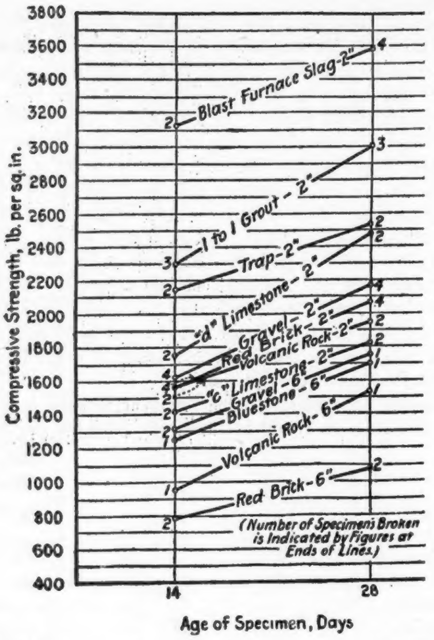


Fig. 1. Compressive Strength of Various Concrete Mixtures.

tion. The work of making the specimens was no better than that under ordinary field conditions of concrete construction, no attempt having been made to enter into any elaboration. Thorough mixing, however, was positively assured, the work being done by hand. The molds used were in gangs of tens and made of planed 1-in. white pine lumber, put together with screws. All concrete was mixed to ordinary work consistency—rather wet than dry.

In the discussion following the reading of this paper, one engineer mentioned several cases where slag for concrete had been rejected, while another, Mr. Unger, cited many instances in large work in iron and steel works in the vicinity of Pittsburgh where slag had been successfully and practically exclusively used. His contention was that the errors, so far as known, are due to lack of knowledge of the material; proper preparation and slow cooling of slag being essential and necessary. Mr. Humphrey pointed out that great caution should be used in the selection of slag and that it should be brittle, dense and free from sulphur.

CONCRETE TRACK ELEVATION BRIDGES TO REPLACE THOSE OF STEEL, ILLINOIS CENTRAL R. R., CHICAGO, ILL.

Old Steel Track Elevation Bridges Between 51st Street and Grand Crossing, Erected in 1893, to Be Removed in Sections and the Latest Type of Reinforced Concrete Structures Erected.

When the Illinois Central elevated its tracks through Hyde Park in 1893 steel spans were used for all subways. These bridges carry eight tracks, two each for through freight, through passenger service, express suburban service and local service. At the time these structures were built considerable allowance was made for increase in size of rolling stock, but even so, the adoption of heavier engines and cars has made necessary the replacement of the bridges.

Concrete is now being used almost exclusively by this road for track elevation work, and the standard type of reinforced concrete deck slab carried on skeleton piers of the same material and plain concrete abutments will be used in the reconstruction. These bridges will be of similar construction to the Flossmoor subway described on page 374 of the September issue and the South Front St. subway, Memphis, described and illustrated in the October issue of *Railway Engineering.*

These new bridges, the noiseless type with ballasted floor, will require a raise in grade of about 1 foot on account of the greater thickness of floor required. Besides replacing the old bridges, two or three additional subways will be opened up for streets heretofore dead-ended at the elevation, thus making a total of fifteen bridges to be constructed.

These structures must be put in without interruption of traffic, which is very heavy, several additional railroads using the Illinois Central tracks at these points, and this adds greatly to the difficulty of the problem of replacement. The plan is to build each of the subways in four longitudinal sections, each wide enough for two tracks, traffic being shifted from these tracks during construction.

Preparatory operations, such as track moving and grading, were started this fall. In the spring a force of 500 men will be given employment. The work will involve an expenditure of about $1,500,000 and it is estimated that a period of about two years will be required to complete the work.

CURRENT PRICES—CONCRETE MATERIALS.

Portland Cement—The cement market has remained practically the same since last month, except in certain localities, and the demand is about the same; on the Pacific Coast the market continues very dull. The grade separation work of the N. P. Ry. at Spokane, involving an expenditure of about $1,500,000, contract for which has just been let, should help the western market for concrete materials. Prices given f. o. b. cars at points named, including cloth sacks, for which, in general, 40c per barrel (4 sacks) is refunded on return in good condition. Prices per barrel (including 4 cloth sacks) are as follows: Boston, $1.72; New York, $1.58; Chicago, $1.55; Pittsburgh, $1.50; New Orleans, $1.64 on dock; Memphis, $1.82; Cleveland, $1.10; Cincinnati, $1.68; Detroit, $1.59; Indianapolis, $1.65; Columbus, $1.67; Toledo, $1.59; Dayton, $1.65; St. Louis, $1.55; Milwaukee, $1.60; Minneapolis and St. Paul, $1.75; Kansas City, $1.63; Omaha, $1.68; Spokane, $1.65; Seattle, $2.30; Tacoma, $2.30; Duluth, $1.78.

Crushed Stone—1½ in. stone, prices per cubic yard, f. o. b. cars in carload lots, unless otherwise specified. Boston, 80c per ton at the quarry; New York, 90c to $1.00, in full cargo lots at the docks; Chicago, $1.00; Spokane, $1.25; Seattle, $1.25.

Gravel—Prices given are per cubic yard f. o. b. cars in carload lots unless otherwise noted. Boston, 75c; New York, 90c in full cargo lots at docks; Chicago, $1.00; Spokane, $1.25; Seattle, 75c; Tacoma, 75c.

Sand—Prices are per cubic yard f. o. b. cars in carload lots unless otherwise indicated. New York, 50c, full cargo lots at docks; Chicago, $1.00; Spokane, $1.00; Seattle, 75c; Tacoma, 75c.

Reinforcing Bars—The demand and prices in general about the same as last month. Pittsburgh base quotations on mill shipments f. o. b. cars are from $1.20 per cwt., with the prevailing extras on bars under ¾ inch or base. The following are quotations on base bars per 100 lbs. for mill shipments from other points, f. o. b. cars: New York, $1.36; Philadelphia, $1.35; Chicago, $1.38; Spokane, $2.20; Seattle, $2.00; Tacoma, $1.80.

Shipments from stock are being made at the following prices per cwt. f. o. b. cars: Pittsburgh, $1.60; New York, $1.85; Cleveland, $1.80; Cincinnati, $1.85; Chicago, $1.85; Spokane, $2.50; Tacoma, $2.00; Seattle, $2.20.

Metal Clips for Supporting Bars—$5.50 to $6.50 per 1,000, depending on size.

For the majority of the prices given we are indebted to the Universal Portland Cement Co., Concrete Steel Co., American Sand & Gravel Co., Chicago, and F. T. Crowe & Co., Seattle, Spokane and Tacoma.

Reinforcing bars for mill shipments are in general sold on a Pittsburgh basis; this is, at the Pittsburgh quotations plus the freight to the point in question, and with the following list of freight rates on finished material and the Pittsburgh quotation given, the prices of bars at any of the points listed can be readily computed.

From Pittsburgh, carloads, per 100 pounds to:

Albany	16 cents	Birmingham	45 cents
New York	16 cents	Columbus	12 cents
Philadelphia	15 cents	Cincinnati	15 cents
Baltimore	14½ cents	Louisville	18 cents
Boston	18 cents	Chicago	18 cents
Buffalo	11 cents	Richmond	20 cents
Norfolk	20 cents	Denver	84½ cents
Cleveland	10 cents	St. Louis	22½ cents
Minneapolis	32 cents	New Orleans	30 cents
Kansas City	42½ cents	Indianapolis	17 cents
		Omaha	42½ cents

New Books

TABLES FOR STEEL DETAILING AND DESIGNING. Compiled by J. A. Auringer. Loose-leaf; leather; 6x8 inches; 168 pages. Published by W. T. Hunt, Jr., 150 Nassau St., New York. Price, $5.00.

This book in the form of a loose-leaf thumb indexed volume consists of 168 blue print pages of tables for steel designing and detailing. These tables include practically all of the American Bridge Company standards together with tables gathered from other sources. Some of the tables can be found in the standard handbooks on steel and they could therefore have been rightfully omitted in this volume. The book as a whole will be found invaluable for the structural engineer and designer and the loose-leaf form makes it very handy to add such tables as are desired, thus adding to its value.

CASPAR'S TECHNICAL DICTIONARY—ENGLISH-GERMAN AND GERMAN-ENGLISH. Compiled by C. N. Caspar. Cloth, 4¾ in. by 6 in. 264 pages. Published by C. N. Caspar Co., 454 E. Water St., Milwaukee, Wis. Price, $1.00 net.

A dictionary comprising the most important words and terms employed in technology, engineering, machinery, chemistry, navigation, shipbuilding, electro-technics, automobilism, aviation, etc., according to the usage and terms of expressions as employed in technical and scientific works. This little pocket book is intended to supplement old or modern general German-English dictionaries, thus filling a long-felt want. The latest technical literature and the best authorities were freely consulted in producing this work. To the engineer who reads technical German but is not thoroughly familiar with all the latest technical terms this book should prove valuable.

ENGINEERING GEOLOGY. By Heinrich Ries and T. L. Watson. Cloth, 6x9 in. 672 pages, 175 illustrations. Published by John Wiley & Sons, Inc., New York. Price, $4, net.

A thorough knowledge of geology is among the most important assets of the engineer, as occasional failures of large structures due to unknown geologic conditions indicating earth slides, tunnel cave-ins, sliding bridge piers and abutments, faulty foundations for dams and buildings and a great number of similar accidents could have been avoided in most cases, had engineer been aware of the true geologic character of the region. In spite of its importance, the subject of engineering geology has been slighted by nearly all engineering colleges in their haste to turn out *engineers* in the short time of four years. The excuse that no suitable text is available is no longer justifiable, since the appearance of this most valuable contribution by Professors Ries and Watson. As a text and as a reference book for the practicing engineer's library it stands without an equal in its field. As the authors state in the preface this book is intended primarily for civil engineers but in order that it may be of use to others interested in applied geology certain parts contain more detail than is necessary for the actual requirements of the former.

The first four chapters treat of rock-forming minerals; general characters, mode of occurrence and origin of rocks; structural features and metamorphism of rocks; and rock weathering and soils; in a very comprehensive and precise manner. Interesting chapters on rivers and underground waters and lakes follow. To the railroad engineer chapter 7, on landslides and their effects, will prove most instructive and valuable as will the one on wave action and shore currents.

Chapter 10 treats of glacial deposits, their origin, structure and economic bearing. Building stone, limes, cement and plaster clay and clay products, are the subjects of three chapters containing much valuable information. Chapters 14 and 15 treat of coal and petroleum and other hydrocarbons. These are followed by chapters on road foundations and materials and ore deposits. Appendix A gives the geologic column and Appendix B a list of Geological Surveys, both state and national.

At the end of each chapter is given a list of references for more extensive reading and study. The topography of the book is excellent, a heavy calendered paper being used throughout.

INFLUENCE DIAGRAMS. By Malverd A. Howe. Cloth, 6x9 in. 65 pages, 42 figures. Published by John Wiley & Sons, New York. Price, $1.25.

This little book is an exposition of the use of unfluence lines for the determination of maximum moments in trusses and beams, the object being to bring attention to the fact that for loads on all ordinary trusses the influence diagrams for bending moments are drawn by following a simple rule, and that no computations for their direct application are required.

Illustrated examples of influence diagrams for loads on simple trusses, double intersection trusses, continuous trusses, arches and beams of constant cross-section are given. These show the wide range of application of the influence diagram for determining moments and stresses in trusses. The clear and concise manner in which Mr. Howe has presented the subject matter make the book valuable as a text and reference work.

RAILROAD ENGINEERING.—By W. G. Raymond, Second Edition, Revised. Cloth, 6x8½ in. 408 pages, 110 figures, 18 plates. Published by John Wiley & Sons, New York. Price, $3.50.

The second edition of this well known work descriptive of the fixed portion of a railroad and giving the underlying principles of the design of its layout has been revised to include the latest data on train and curve resistance, rise and fall, and the new expense items of the Interstate Commerce Commission, besides correcting all known errors of the first edition. A lighter paper has been used and the book considerably reduced in size. In a word, the book has been considerably increased in value by the changes.

The book is divided in three parts as follows: Part I, Permanent Way; Part II, The Locomotive and Its Work; Part III, Railroad Location, Construction and Betterment Survey. The first part treating of track materials, culverts, bridges, turnouts, yards and signaling, has not been revised. In Part II the material relating to train resistance and allied subjects has been rewritten as a result of the elaborate experiments on train resistance by Professor Schmidt. The third part of the book, on location and betterment surveys, is the same as in the first edition.

The book, intended primarily for students, is very well written and treats the various subjects in such a manner as to make it a handy reference volume for the railroad engineer and especially so to those engaged in location and relocation work.

"Physical Valuation of Railroads," by William J. Wilgus, proceedings American Society of Civil Engineers, May, 1913, Vol. XXXIX.

"Railroad Valuation," by D. F. Jurgenson, chief engineer Minnesota State Railroad Commission, Journal of the Association of Engineering Societies.

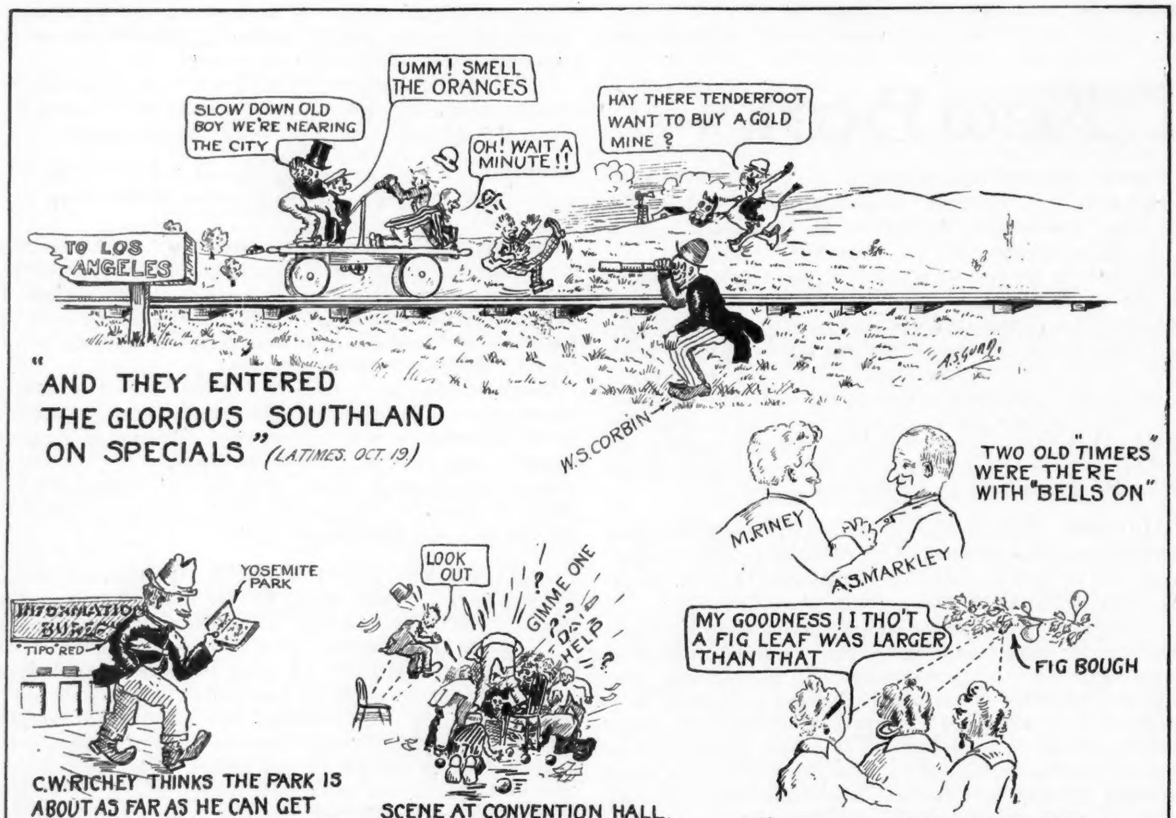
"Railway Capital and Real Value," by Darius Miller, late president C., B. & Q. R. R.

"Valuation of Public Service Corporations," by Robert H. Whitten; 800 pages, N. Y., 1912.

"Valuation for the Purpose of Rate Making." Report American Society of Civil Engineers, Jan. 21, 1914.

The Engineer's Distress

A. S. Gunn Editor



The Maintenance of Way Department

Annual Convention of American Railway Bridge & Building Association

The Twenty-fourth Annual Convention of American Railway Bridge & Building Association was called to order October 20, at 10 a. m., by President J. N. Penwell, in Los Angeles, Cal.

Opening addresses (or addresses of welcome) were made by H. V. Platt, assistant general manager, and W. H. Whalen, superintendent South Pacific Company. Responses were made by L. D. Hadwen. The subjects reported upon were: Ice houses; bridge warnings; reinforced concrete bridge work; care of traffic while constructing bridges to eliminate grade crossings; water supply; concrete posts, poles and signs.

The following subjects not reported upon were carried over to be reported upon at the next convention, *i. e.*, railroad crossing gates; towers, etc.; station buildings for passenger service only; mechanical coaling station; concrete culvert pipe, and concrete piles.

The subjects which were reported upon were thoroughly discussed.

About 130 members were in attendance, and 40 new members were voted in.

A. E. Killam, G. E. Hanks and Wm. Ross were elected life members.

The following officers were elected for next year:

President—L. D. Hadwen, engineer mason construction, C. M. & St. P.

First Vice-President—G. Aldrich, supervisor B. & B., N. Y., N. H. & H.

Second Vice-President—G. W. Rear, general bridge inspector, Southern Pac.

Third Vice-President, C. E. Smith, assistant chief engineer, Missouri Pacific.

Fourth Vice-President—E. B. Ashby, chief engineer, L. V. R. R.

Secretary, C. A. Lichty, inspector purchasing, C. & N. W. Ry.

Treasurer—F. E. Weise, C., M. & St. P. Ry.

Executive members—W. F. Steffens, N. Y. C. Lines; S. C. Tanner, B. & O.; Lee Jutton, C. & N. W.; W. F. Strouse, B. & O.; C. R. Knowles, I. C. R. R., and A. Ridgway, D. & R. G.

It was decided to hold the next annual convention at Detroit.

Following is the list of subjects for next year:

1. Locomotive cranes.
2. Pile and timber trestles.
3. Railway water tanks.
4. Coaling stations for handling 25 to 50 tons per day.
5. Costs of structures.
6. Efficient methods of handling work and men.
7. Warnings for overhead and side obstruction.
8. Reinforced concrete bridge work.
9. Station buildings for passenger service.
10. Concrete culvert, pipe and concrete piles.
11. Highway crossing gates, towers, etc.

There were no exhibits by supply companies.

A banquet was given to the members and their friends by the members of the Pacific slope at the Hotel Alexandria Tuesday evening. After the business session Wednesday afternoon, a trip was taken to Redondo Beach, and Ocean Park.

Thursday afternoon the entire party took a trip to Mt. Lowe.

RAIL CREEPING, No. 19.

A. H. Sandusky, Roadmaster.

Creeping track is something that has to be contended with on most all heavy grades, if they are of any length, and occasionally anti-creepers or anchors are not applied until steel has run out of slot spikes and bunched the ties in places.

I have used anti-creepers very successfully for the past six years on grades from six-tenths to one and a half per cent. If the anti-creepers are put on before the rail begins to creep it only requires about half as many to hold it as it does if the rail has started. It is a good plan to put on enough anti-creepers to take the weight off the slot spikes in order to prevent tearing the ties and working up the spikes in the slots. If the rail is permitted to run until the slot grips the spike the spike will soon work up.

My experience has been that the rail on tangents begins to creep first and drifts down on the curve and will lodge there until it gets tight enough to break away, and in the meantime it is liable to make elbows in the curve and cause joints to look sharp. They will show up on the inside rail of the curve more than on the outside rail. Every trackman knows what the result is if rail is permitted to creep.

Near the top of the grade the expansion will run out as far as the bolts will permit, and if this condition is allowed to remain for any length of time battered rail is the result. While near the foot of the grade and in sags and on curves there will be no expansion and if the condition is not relieved before the hot season of the year approaches there will be trouble from kinked track, and if there are many bad ties in the track there is great danger of track spreading. Of course this is about the last stage of creeping track and it scarcely ever gets this bad except on unimportant lines where track is not kept in first-class shape. The only way to fix it is to re-distribute the expansion and re-space the ties and apply anti-creepers.

I have found that about the cheapest way to do this work is to commence in the spring as soon as the heat kinks appear, when it is hot enough to lay track without expansion, and begin at the foot of the grade, break a joint and make a switch point connection; this will permit the rail to straighten out for half a mile or so each side of the connection, if the spikes around the joints have been removed. If it does not straighten out go back a quarter of a mile or so from the connection and drive it; use a rail for a battering ram; a few hard blows will be sufficient to take all the heat kinks out. When this is done apply enough anti-creepers to hold the rail in place; cut a rail to fit in at the switch point connection and take the point and go up the grade three-quarters of a mile and repeat the dose.

When you get near the top of the grade and come to where there is too much expansion, loosen all the bolts in each joint and make a switch point connection and drive the rail each way as far as you can; it will drive down hill much easier than up hill, but by driving ten or twenty rails at a time it will not take long to close up the expansion. When this has been done apply the anti-creepers and proceed as before. The ties should be spaced under the joints promptly, and you will find there will be no more creeping track if the work has been thorough.

From two to four anti-creepers per rail will hold track from creeping on any of the above grades, if applied before the rail has started to creep, providing it has been laid with the proper expansion. It is a good plan to apply an anti-creeper or two on each rail when re-laying steel on grades in order to hold the expansion until ties have been spaced under the joints and slot spiked. If this is done it is not necessary for the gang spacing the ties to follow the re-laying gang so close.

I do not know of any one thing that has any more train accidents to its credit than creeping track. It causes too much expansion on part of the track and no expansion whatever on other parts. Too much expansion causes open joints, broken rail and

car wheels. It is not an uncommon thing for an open joint to pull apart from four to six inches in one night. No expansion causes tight gauge, kinked track and frogs and switch points displaced to such an extent that a flange will often climb them.

It is a fact that incompetent foremen are sometimes in charge of track-laying gangs and do not give rails enough expansion, but they most always get enough that rail will not creep if they are properly anchored. I do not know of any material a railroad buys where they get as much good out of it, considering the amount of money expended, as they do from a good anti-creeper.

I have had some trouble in the past with anti-creepers falling off during the winter. This can be overcome to a great extent by digging the ballast from around the anti-creeper so they will not come in contact with the frozen ballast when rail contracts during cold weather.

RAIL CREEPING, No. 20.

By V. H. Shore, Foreman.

Rail creeping is an evil that has bothered railroad companies as long as they have used iron and steel rail. My experience with this trouble has been that I haven't known any anti-creeper that entirely eliminates it, but there are several kinds on the market that greatly reduce it, especially on double track, where the traffic is practically all in one direction, and on grades on single track.

The most of our trouble from rail creeping occurs where we have considerable changes in grades, or, "up hill and down hill," so to speak, and through yards where it affects main-track switches. I do not think anti-creepers, in general, do much good on single track, on account of trains running in opposite directions.

The most of our rail creeping on level grade is due to the heavy weight of the locomotive or load having a tendency to roll or crowd the rail ahead of it when moving, so it would be moved in one direction by one train and in the opposite direction by a train moving in the opposite direction.

On grades, the rails always creep toward the lower end or down hill on account of traffic down grade crowding it ahead and traffic up grade (heavy freights) drawing it down by the adhesion to the rail of the drivers of the locomotive pulling the heavy load. I have experienced considerable difficulty from rail creeping between two heavy grades, where the steel was very tight from this cause, and found good line impossible to maintain in hot weather. In one case we had to put in a pair of switch points to prevent a "kick out." This is an exception, where anti-creepers can be used on single track to good advantage. The anti-creepers should be put on when the rail is laid, or relaid, as the case may be; the number per rail varying with the amount and kind of traffic and gradient of track. With heavy traffic and a 1% grade or over, an anti-creeper to each tie on each rail is not too much.

I think the mistake is too often made of not putting on anti-creepers at the proper time; that is, not until the steel has been allowed to run before they are installed, and by the time we get them on and they become set, the steel is so tight that they are apparently of no service; then the anti-creeper is condemned and taken off. To give any type of anti-creepers a fair trial, they should be put on when rail is first laid, and fairly placed against the tie, allowing expansion enough at bottom of grade so that rails could creep a little until anti-creepers become firmly set on rail and against the tie. I have seen this tried out with excellent results.

On double track, where traffic is all in one direction, anti-creepers give good service when installed at the right time and properly placed. The anti-creeper should be placed against the opposite side of the tie in the direction of traffic; that is, the flat part of the anti-creeper against the west side of the tie on east-bound track, and on the opposite side on west-bound track, with the exception of ascending grades, where they should be placed on the west side of tie on an ascending grade on east-bound track, and on the east side of tie on an ascending grade on west-bound track, the number per rail being governed by traffic and grades.

Where track has little or no grade and is rock ballasted, one anti-creeper to every fourth tie gives good results, providing the joints are anchored. One anti-creeper to every other tie is necessary on dirt track or light ballasts. The kind of anti-creeper that I have seen used most is the P. & M. boltless, but I think any anti-creeper that will clamp to the rail securely, and which is put on before the rails have been allowed to creep much, will give good service. I am inclined to believe that in a great many cases the anti-creeper has not been given a fair trial. I have known foremen to place them between two ties and the anti-creeper was four or five inches from the tie that it should set against, and chances were that before the rail crept enough to bring it against the tie, that anti-creeper had come apart and fallen off, as most of them depend on some resistance to clamp them to the rail firmly.

I had five years experience as section foreman on a road (C., R. I. & P.) that used 85-lb. spring rail frogs equipped with the Ajax anti-creeper toe block. I can say we never had any trouble with our frogs from rail creeping, causing spring rail to become bound in guide boxes, and thus remaining open. The turnout rail is attached to the main-track rail at the heel of the switch point by four long bolts that run through the heel block between rails at heel. The spring rail of the frog is connected to this same main-track rail at the toe of the frog. As side tracks are usually laid without much attention being paid to expansion, and of lighter rails than main track, they have too much expansion and the turnout rail on stock rail side creeps in the direction of the siding, account of heat and traffic and the main-track rail on this side being attached must go with it. This, of course, crowds the projections on the spring wing rail of the frog against the guide boxes, causing them to bind and wing does not move freely as it should. In hot weather these spring rails become bound so tight in the guides that an engine or train entering the siding and passing over the frog, bends the spring rail out, when the wheel enters at the point.

The Ajax toe block overcomes this difficulty. It is bolted securely to the toe of the frog with eight heavy track bolts, so when one rail creeps the entire frog must move correspondingly. It is made of a very heavy cast iron, with three heavy ribs running diagonally across the top, giving great strength. The block is perforated between the ribs to allow water to escape.

Some spring rail frogs are equipped with a small hinge device from fixed wing rail to movable wing rail, in the mouth of the frog, but in my experience I have found them inadequate.

The Ajax toe block can be attached to the toe of any spring rail frog and is made to suit the offset in joints, and right and left-hand frogs. I have experienced their use under very heavy traffic and speed, both in hot and cold weather, and bottom of grades, and never had any trouble with spring wing rail standing open or becoming bent out at point of frog. To get best service out of them the bolts must be kept tight on the toe block.

TRAINMEN AND TRACK CONDITIONS.

By J. T. Bowser, Maintenance of Way Department, Queen & Crescent Route.

Have trainmen *anything* to do with track conditions? They most certainly have, and, furthermore, they can play a most important part in the efforts of the maintenance of way department to keep track in a safe and good riding condition.

With the proper attitude on the part of officials and subordinates in the maintenance of way department, a cordial relation and a good working arrangement may be easily established with train and engine men.

Maintenance of way department employees should make it a point to know personally as many as possible of the train and engine men (particularly the latter) whose runs take them over the tracks under their supervision. With the proper encouragement these men will gladly report promptly any places which may be riding roughly or look as if they might give trouble.

Try this and it will be found that in a short time enginemen will be stopping the roadmasters or road supervisors, or even coming to the division offices, to say "She rode a little rough just north of ——," or "You had better get old 'Pat' over on the south

end of his section; there are a couple of kinks down there that gave me a bad jerk today."

Wire reports, filed by conductors or enginemen at way stations, will begin to come in, "Bad place at M. P. ***." They will throw off notes to the foremen or even stop and tell him if the place happens to be very bad. They learn section limits and get interested in track work. You hear at the engine house, at the yard office, at the eating houses advice or warning shouted to the outgoing by the incoming crews: "A little rough in ——— dip; better ease down into it tonight. I told the roadmaster about it."

This coöperative spirit can be greatly encouraged by sending supervisors and section foremen over their territories "to see how she rides." Nothing will find the bad places for them like a large engine at a good speed.

A great portion of the value of this coöperative spirit lies in the fact that these reports will enable the maintenance of way department to get at these places before they get bad, but perhaps a greater value lies in the interest aroused among the trainmen. They become more familiar with track matters and consequently more interested. This will tend to make safe and careful runners of the enginemen, speeding up perhaps where speed is safe, but careful under conditions not so good.

NEW YORK CENTRAL STANDARD 105-LB. RAIL SECTION.

Designed by P. H. Dudley, C. E., PH.D., Consulting Engineer N. Y. C. & H. R. R. R.

The New York Central has tried out a new 105-lb. rail section designed by P. H. Dudley, consulting engineer for rail, tires and structural steel for that company. The principal feature of this new section is the increase of metal at the base of the web, or, more properly speaking, at the conjunction of the web and flange.

The rail section is the former 100-lb., modified by an increase of the fillet to 1 inch at the junction of the web and base, and thickening the web to ⅝ of an inch.

The 100-lb. rail was designed in 1890, and it was adopted by the New York Central and rolled in 1892. The Dudley 100-lb. has rendered excellent service in the tracks of the New York Central and Boston & Albany railroads.

The Dudley 100-lb. rails were rolled for many years out of 0.06 phosphorus and 0.60 to 0.65 carbon. This composition was continued for a number of years until the low phosphorus ores available for Eastern railways were all exhausted.

The 100-lb. rails were rolled for a few years out of under 0.10 phosphorus and about 0.50 carbon. These were more fragile than the original 0.06 phosphorus Bessemer rails. A change was made in 1908 to basic open hearth steel for 3,000 tons of the 100-lb. section, in which the phosphorus was not to exceed 0.04. These rails did not break in temperatures of 30 to 40 degrees below zero.

Specifications were prepared in 1909 for basic open hearth rails to be made under the New York Central elongation and ductility tests. The enlargement of the fillet for the original 100-lb. was made in September, 1912, to strengthen the base and also secure a slightly higher factor of the moment of inertia to reduce the unit fiber stresses in the rails. The general dimensions of the section remained unchanged, and it was only necessary to revise the splice bars to fit the 105-lb. rails to be laid in conjunction with the former 100-lb. without other changes except in the splice-bars. This has saved many thousands of dollars in track fittings which would have been required with any modification of the base of the rail.

There were in the tracks of the New York Central Railroad on January 1, 1914, 67,460 tons (408 miles) of 105-lb. rail, and during the extremely cold weather of January, February and March of this year to August 1 there was not a broken base or half-moon failure in this section.

It is understood that the new design of splice bar designed for the 105-lb. rail is interchangeable with all other sizes of rail cross-sections.

We are indebted to Geo. W. Kittredge, chief engineer, and Dr. P. H. Dudley, consulting engineer of the New York Central, for the information contained in this description.

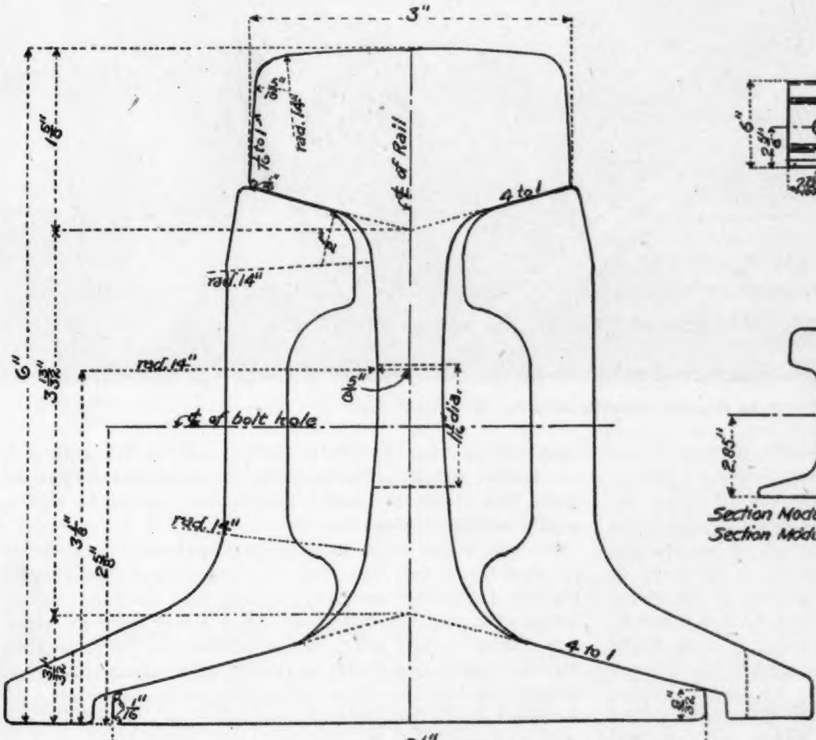
DRILLING DIAGRAM

Section Modulus, head..15.89
Section Modulus, base..17.53

Proportionate Areas.

Head	40.9%
Web	24.5%
Base	34.6%
Total	100.0%

Total Area..10.28 sq. ins.



New York Central Standard 105-LB Rail Section

WAR NEWS: FALL TACTICS REPULSING WINTER'S ATTACKS.

By J. J. Morgan, Kingston, N. Y.

The great European war, emerging as it were from amidst the very essence of peace and prosperity, surprised us beyond comprehension. Evidently we were unaware of the fact that the nations involved have been fully prepared for such a conflict for many years. Hence, the almost instant mobilization of millions of trained warriors was a very simple matter. The precision and effectiveness of the various maneuvers indicate conclusively that this is merely the final staging of a great drama many times rehearsed. A few short weeks from today will find us in combat essential for the existence of good track, especially during the fall and spring seasons, in order to carry off the great volume of water resulting from continued rain. If due attention is given to drainage it will certainly prove a tower of strength for the defense. In order that the track may hold its line for any length of time it is necessary that we impart added strength to the shoulder. This will also tend to lessen the effects of frost and assist greatly in keeping the track in easy riding condition for the passage of trains. Unsafe embankments should be watched closely during the rainy season. Sudden frost followed by rain may work havoc at such points. Should a washout seem probable the necessary material should be placed in readiness at the nearest available point for emergency use so that there will be the

Track Ready to Repulse Winter's Attacks, New York State.

with winter—the avowed enemy of the Knights of Steel. If we were wise in our judgment we also have been placing ourselves in readiness to meet the attack. The fall season places at our disposal an excellent opportunity to launch the final movement in the reinforcing of our defenses and the completing of preparations, so that there will be no question as to our ability to overpower the enemy. Fall, therefore, is a time of final preparation for winter.

The condition of track must, of course, be given first attention. While tie renewals and the surfacing and lining of track should have been attended to in the summer months, nevertheless it is possible that these items have been neglected; the time is growing short for the completion of this work. Alert supervisors will see that the foremen have placed the track in perfect gauge and that adequate drainage has been provided for. Drainage is absolutely

least possible delay to traffic in case of trouble. This is, indeed, an excellent season for the repairing of embankments. Material taken from ditches and from clay and rock cuts can be used to good advantage in this connection.

One of the most important steps in preparation for the winter period is the removal from track of all rails which show even the slightest defects, for such imperfections may result in complete breaks when they encounter frost. Also a very thorough inspection of rails in track after the first cold snap is highly essential. Internal defects, not visible to the eye of the trackwalker, may assert themselves after these sudden changes in temperature. All concerned should put forth their best efforts to eliminate the possibility of derailments due to broken rails. Track fastenings must also be given their share of attention. Splices, bolts and spikes

should be renewed where necessary, and in tightening bolts due provision should be made for the expansion and contraction of rails.

It is a common occurrence for foremen to overlook the ordering of material until it is actually required for use; for example, the first snow squall is usually followed by a deluge of requests for snow brooms, shovels, etc. Now is the time to get a line on what material is needed for winter use. Therefore, the foremen should be instructed to have a sufficient supply of snow brooms, snow shovels, track shims, etc., on hand in due time. An unequipped army is more of a detriment than a help. A barrel or two of sand placed in the tool house while the ground is soft will prove an invaluable facility for use on icy platforms and sidewalks.

With track taken care of we will now discuss the subject of "keeping up appearances." A neatly kept division has great weight with inspectors in the forming of their decisions and has a tendency to cover up, so to speak, some of the weak spots, and places the standard of a division on a higher plane generally. To attain this end it would be a good plan to designate a certain period in which the entire division would be placed "in order"; rails placed on rail rests, and all other material, such as splice bars, bolts, spikes, etc., picked up and placed under cover. Where material is scattered promiscuously along a division and allowed to remain there until winter sets in, resulting in its being covered with snow, it is sometimes the cause of serious handicap, especially in the event of derailments or other emergencies, when material is required for immediate use. Old ties should be burned and great care exercised in burning them, so that there will be no danger of the fire spreading to adjacent fields, meadows, etc. Burning ties on cinder fills should not be tolerated. Nothing should be overlooked in this general cleanup; material, rubbish, etc., of every description should be properly disposed of, old tools assembled and forwarded to headquarters to be placed in good condition for another season. The appearance of a division as a whole should be taken into consideration. A uniform ballast line has a beautifying effect. These and many other items must be looked after in order to properly "keep up appearances." Compared with the condition of track, appearance is but a secondary consideration. Nevertheless, we can plainly see that this subject is wide in its scope and important in its effectiveness. Let's get the cleanup spirit.

The erection of snow fences we find included under the heading of fall work in preparation for winter's attacks. The time is opportune for this work, as the lumber is well seasoned and better results are bound to ensue if this matter is taken care of in the fall of the year.

The labor question is also brought into the limelight in connection with fall developments. The laying off of large extra gangs, as well as the reduction of section gangs, usually result in the loss of many efficient laborers. On account of the difficulty in securing the services of experienced men, they should be urged to return the next year and as many as possible retained in the permanent section forces. The need of such action is very evident at this particular time. No doubt in some parts of the country labor has already felt the effects of the great war. The possibility of Italy becoming involved must not be overlooked. If such a complication arises a scarcity of track labor seems inevitable. Now is the time to act.

Foresight is the secret of preparedness.

Thus fortified by excellent track conditions, flawless rails and fastenings, adequate drainage and reliable shoulders, with an efficient and fully equipped force at our command, we can rest assured that our line of defense will be impregnable, even more so than were the forts of Liege.

RAIL CREEPING, NO. 21.

By Chas. L. Van Auken, Engineer, Track Necessities Co.

Almost all phases of rail creeping have been discussed in your columns by your correspondents, but I haven't noticed any one mentioning having trouble with cross-overs, on account of this, on double track. Several years ago I had charge of a section in connection with a large yard on a double track system.

The movement of trains on double track being all one way on each track causes the rails to creep in opposite directions—that is, the rail on the east bound track will move east, while that on the west bound will move west. This causes the frogs at the cross-overs to move towards each other, thus disarranging the alignment between them.

A cross-over, located about a half mile outside the yard limits, on the section above referred to, controlled by the old fashioned semaphores, operated by hand and interlocked with the switches, controlled the movement of trains over this "plant."

The rail creeping was exceptionally bad at this point on account of nearly all trains either stopping or "pinching" down when approaching.

The frogs were of the spring rail pattern, with plates riveted to them in which were slots for spiking.

The rails would shove these frogs towards each other until the ties to which the slotted plates were spiked would break, and the alignment of the cross-over would get so bad that it would be necessary to drive back the expansion for a half mile or more, on each track, in order to get the frogs the proper distance apart to give the correct alignment.

The ballast at this time was not much better than sand and offered very little resistance to the ties, which made the conditions just right for maximum rail creeping.

This could have been partially, if not altogether, avoided by the use of anti-creepers, but we had nothing of the kind at the time.

At this same place I had charge of track across a long bridge over the Mississippi River. The structure, including a trestle approach from the east, was about three-quarters of a mile long. At the east end of the approach our track curved sharply, the line of another road which operated trains across the bridge connected to our track at the point of curve, leading off on a tangent, laid with light rail.

The south rail of our track connected with this light rail; the consequence was that the heavy rail (which was 90 lb.) shoved the lighter and caused trouble, continually getting the joints on the bridge "out of square," as the north rail connected all the way with the heavy material, and also with the curve, did not move.

Each spring it would be necessary to drive the expansion from the east end of the approach back to the draw span, which was about half a mile. It would take three and a half or four feet of rail to fill the gap made by this process. To take care of this expansion through the winter the following method was used: When the rails were pulled as far apart as they could be without shearing the bolts for several rail lengths, two-inch 'plugs" or "Dutchmen" would be put in, driving up enough expansion to admit one at one or more joints; angle bars, drilled for this purpose, as well as plugs, were kept ready at all times for these emergencies. And watch it as close as we might, there were times when the bolts would shear off and the rails jump six or eight inches apart at a bound. At such times we had to hold trains until this could be remedied. These breaks nearly always occurred when the weather was very cold and stormy; many and many a night I have been called out with the mercury below zero, the wind blowing a gale, the ties on the bridge coated with ice, to put in these "Dutchmen" to make the track safe for the passage of trains.

As in the other case we had no anti-creepers, and if we had them it is doubtful if the officials would have let us use them on the structure, as it was thought then, and is to a certain extent yet, that it is not practical to put them on a bridge of any kind, although we tried anchoring the rails to the floor beams of the bridge by the use of straps bolted to them and to the rails, which would have the same effect on the bridge as the anti-creepers, but this did little good in stopping the movement of the rails and had no perceptible effect on the bridge.

A more recent experience, which goes to show the difference in methods of today and those of a couple of decades ago, brings us up to date. This occurred during the construction of a new line.

This line was laid with 90-lb., A. R. A. rail 33 ft. long, white oak ties, 18 to 21 to the panel, according to size; heavy angle bars, punched so as to "stagger" the bolts, of which there were four to the joint, and heavy channel base plates, joints laid square. The work was done with a track machine. The expansion was watched very closely; a thermometer was carried on the machine and the temperature watched for variations, the expansion shims being changed to suit weather conditions and the temperature of the rails. Also care was taken to keep the joints square, especially so when approaching a bridge, as the least variation shows plainly when laid on the ties on a structure. I mention this in order to bring out more clearly the trouble from creeeping at bridges. At a place where the track crossed a trestle and bridge 2,000 ft. in length, we had trouble with the rails creeping. There were high fills at each end of the structure, which had not had time to settle solidly before the track was laid—in fact, at one end we had trouble with the embankment sliding. There was only one steel span, the balance of the structure being a heavy frame bent trestle resting on piling. The general direction of the road was north and south.

When we began to run gravel trains the rail on the trestle began to give trouble. The heavy traffic was all one way, south bound, and the east rail went with it, so much so that it became necessary to drive it back; sometimes not over ten days would elapse after the rearrangement before it would run enough to shear off the bolts. The only way I could account for this one rail creeping while the other one hardly moved was that there was a long one-degree curve ending about 600 feet north of the bridge, and the wheels under the heavy cars did not get straightened up after leaving the curve before they struck the track on the bridge, consequently were binding on the east rail and carried or drove it ahead. The ties on the trestle were spaced 4" apart and were spiked in full in the effort to prevent the creeping, but with little effect. As soon as anti-creepers could be obtained they were placed five to each rail from the point of curve nearest the bridge onto and across the structure, except on the steel span.

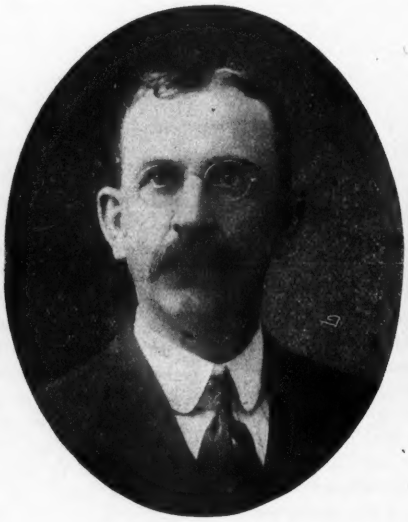
This ended the trouble and, contrary to the expectations of some of the engineers, did no damage to the structure, as there was no perceptible movement of any part of it from this cause.

On this same construction the new line crossed two other steam roads at grade. At both of these points "creeping" got in its work and shoved the crossing frogs on the old roads, out of line. The crossings in both instances were nearly right angles.

The gravel pit was located at the north end of the line and all the ballast was hauled south for 100 miles. The first crossing was 20 and the second 40 miles from the pit. The gravel was rather fine and did not offer as much resistance to the ties as coarser material would have done, consequently the movement of the track towards the crossings was very pronounced, and they were shoved out of line as soon as the trains began running. The first really hot day put them in such shape that the old lines were unsafe and they were lined back only to creep ahead again with a few days' traffic. They were lined back and a switch point installed on each rail on the north side of the crossing, entirely relieving the pressure from the frogs; this prevented any further trouble with the alignment of the foreign lines. The switch points were left in until the heavy hauling southward ended and the weather became cool, then they were removed the rails sawed off and replaced. The thought may arise in the minds of some readers that the expansion would be spoiled by having the switch points in and giving the rails the chance to run. In these cases there were only a few joints next to the points that we found expanded far enough to need driving back. Anti-creepers were placed on both sides of these crossings as soon as they were received. I am in full accord with one of your correspondents who said that it would save the railway companies both time and money if they would furnish anti-creepers and have them installed before there was enough traffic on the newly laid track to start the creeping, as driving back rail and respacing ties is slow and expensive work.

Officers of the American Railway and Bridge Builders' Association

L. D. Hadwen, C., M. & St. P., President.



G. Aldrich, N. Y., N. H. & H., First Vice-President.

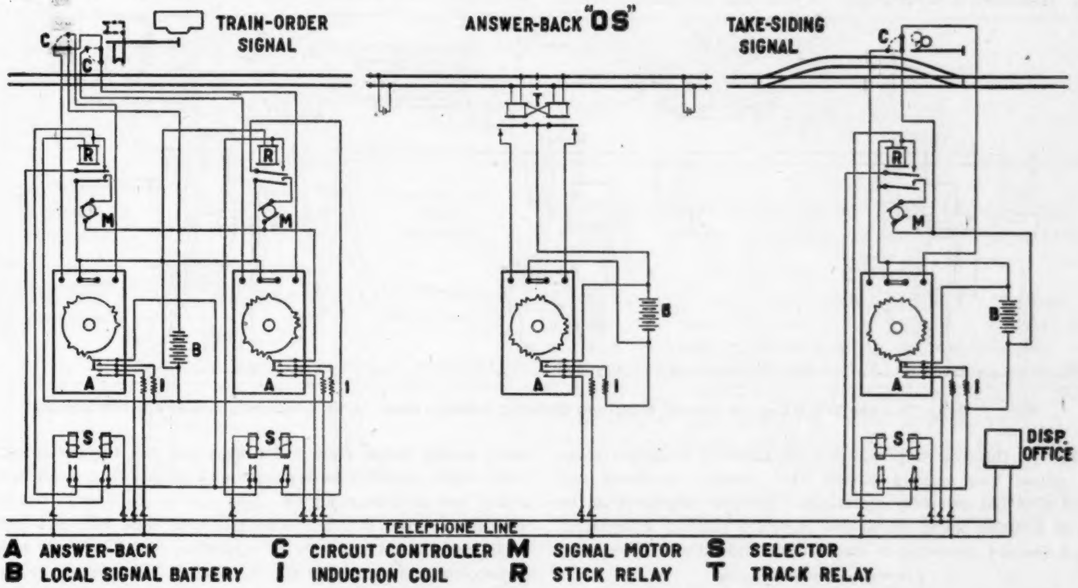
C. A. Lichty, C. & N. W., Secretary.

The Signal Department

DISPATCHERS' SELECTIVE SIGNALING SYSTEM.

The General Railway Signal Company has issued an "Advance Notice" pamphlet describing a "Dispatcher's Selective Signaling System," which has recently been perfected by their engineers and is principally designed for handling traffic on single track lines that are not prepared to install automatic block signals. In this system the dispatcher controls train-order signals and take-siding signals located at predetermined points on the division, and can determine at the switch board, whenever it is desired, the actual indication displayed by each signal. In addition the system may be utilized to indicate to the dispatcher the passing of a train by a particular point, thus superseding the present "OS" or train report telegraph signal of the operator.

Fig. 1 Fig. 2 Fig. 3



Circuits: Dispatcher's Selective System.

The control and operation of such signals is comparatively simple, but safety requires some reliable means for indicating to the dispatcher the movement of the signal from normal to reverse position and from reverse to normal position.

A special answer-back mechanism accomplishes this important function by sending in to the dispatcher, when he operates the proper key, a distinctive series of audible code-impulses which can be repeated as often as the dispatcher desires.

The principal uses to which the Dispatchers' Selective Signaling System is adapted are briefly described in the following paragraphs:

SELECTIVE CONTROLLED TRAIN-ORDER SIGNALS.

This arrangement affords great economy, as many train-order stations can be operated without any operators, and at other stations the number of operators can be reduced to one or two, resulting in a large reduction in the division pay-roll. This arrangement also affords facility in that train-order stations can be established at many places where traffic conditions would not warrant the expense of one or more operators.

Fig. 1 shows a selectively controlled train-order signal system and the appliances used. Each arm of the signal is controlled by two keys—one for normal position and one for reverse position—in the dispatcher's office, through the telephone wires, the contacts of selector S, and through stick relay R. Current for operation of signal motor M is supplied by local battery B.

When the signal has operated from one position to another, circuit controller C, on signal mechanism, closes a circuit through battery B and answer-back mechanism A which begins to operate, clockwise for one position of the signal and counter-clockwise for the other position. The operation of the answer-back mechanism produces a distinctive series of audible impulses which are transmitted to the line and the dispatcher, informing him that the signal has operated and that the proper indication is displayed.

ANSWER-BACK "OS."

This arrangement affords an efficient means of indicating to the dispatcher the passing of trains at certain points, where, for example, operators are on duty during the day, or during heavy traffic. The combination of selectively controlled train-order signals and answer-back "OS" arrangement affords practically all the advantages of a train-order station without the expense of the operators' wages.

Fig. 2 shows an answer-back "OS" arrangement which comprises an answer-back mechanism controlled from two short adjoining track circuits. When an approaching train enters one of the track circuits, the respective armature drops and closes, through a back contact, a local battery circuit through the answer-back mechanism which operates and produces a distinctive series of audible code-impulses for each direction. With one track-circuit section and an ordinary track relay the answer-back mechanism would give the same indication for trains in both directions.

The answer-back mechanism may be arranged to indicate every passing train, or to indicate only when dispatcher turns the proper key. The indication is transmitted by the telephone wires.

TAKE-SIDING SIGNALS.

This arrangement affords a convenient means of displaying to certain trains an indication to take siding at points other than scheduled meeting or passing points. When stopped by a take-siding signal, trainmen can communicate with dispatcher by telephone and obtain definite orders or instructions.

Fig 3 shows a take-siding signal with its answer-back mechanism

and control devices which are practically the same as in the selectively controlled train-order signal. Also the answer-back mechanism operates as in the train-order signal and indicates the normal and reverse position of the signal.

Several answer-back mechanisms have been in actual service for several months in connection with take-siding signals, and the highly satisfactory results indicate that the selective control of signals is going to be an important factor in future signaling methods.

GRAY-THURBER SYSTEM OF AUTOMATIC TRAIN CONTROL AS APPLIED TO AN AUTOMATIC SIGNAL SYSTEM.

As regards the method of applying the Gray-Thurber System of Automatic Train Control to an automatic signal system: Due to the fact that nearly every railroad employs a different scheme of installation for their automatic signal system, it, of course, requires a study of each system, and also of the traffic, in order to design a proper combined automatic signal and train control system. However, it is arranged to have the automatic control

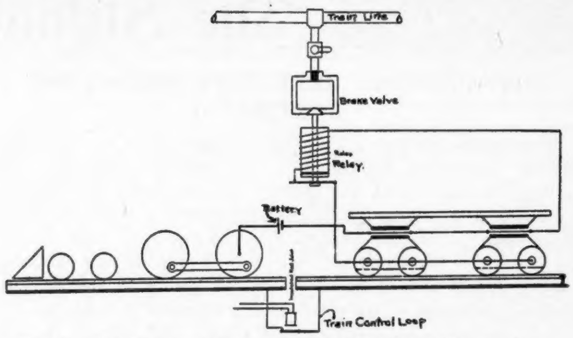


Fig. 3. Showing Principle of Electrically Operating System.

matic signal circuits are patterned after those employed by railroads that have a full block overlap. A full block overlap would not always be advisable, especially where the blocks are long. Here the overlap might best be only braking distance. This automatic train control is the development of several years of

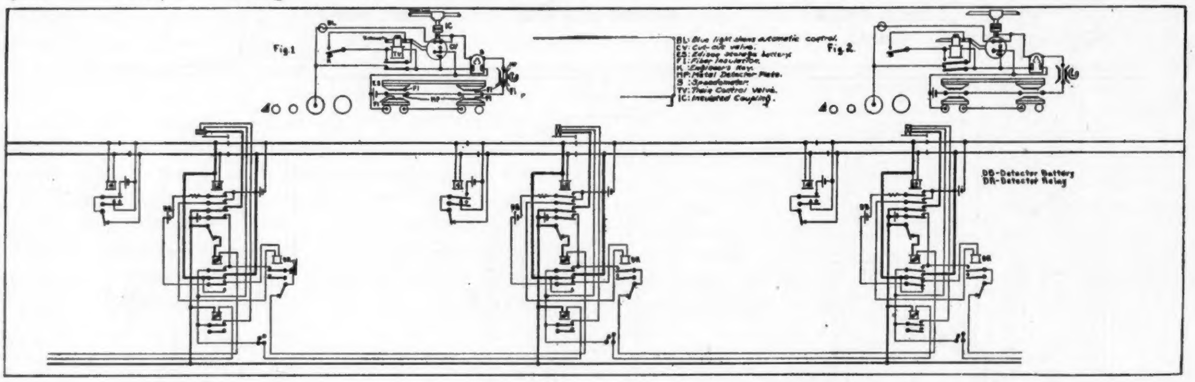


Fig. 1. Gray-Thurber Train Control Circuit Diagram, Showing Control Over Three Automatic Electric Block Signals

take effect at the first stop signal when entering a danger zone. Fig. 1 shows two engines having their tender insulated and equipped with the necessary apparatus. The first engine is in the middle of a block, while the second engine is passing a signal at stop and thereby receiving a stop engine indication. The automatic

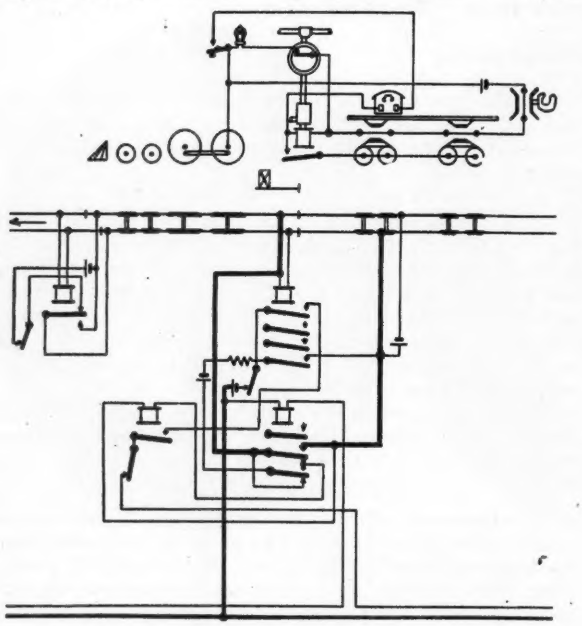


Fig. 2. Diagram of Wiring on Engine Necessary When Applied to Automatic Signal System.

tests, during which time it has been the aim to develop an automatic train control that is simple and safe, with a small first cost, and a low maintenance; one that can be applied to the present equipment with but few changes and that will not interfere with the present methods of operation but that will meet the requirements adopted by the A. R. A. This system relies upon the automatic signal for visual indication and does not interfere with the enginemen in the control of his engine unless he unwittingly enters a danger block at high speed. In which case, the train control steps in and brings the train to a stop by a service application of the brakes, after which the engineman is permitted to again take control of his train. Believing that an engineman will not maliciously place his train in danger, it seems that an automatic train control system furnishing one stop will obviate the "taking a chance," and is sufficient to bridge the gap of failure to properly observe the signal indication. The scheme shown on the plan uses D. C. throughout. It is to be understood,

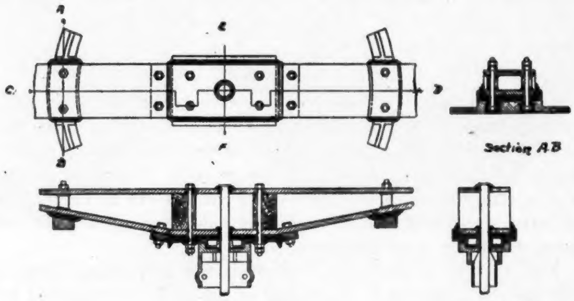


Fig. 4. Cross Section of Body Bolster in Electric Traction Car, Showing Detector Plate and Fibre Insulation.

RAILWAY ENGINEERING AND MAINTENANCE OF WAY

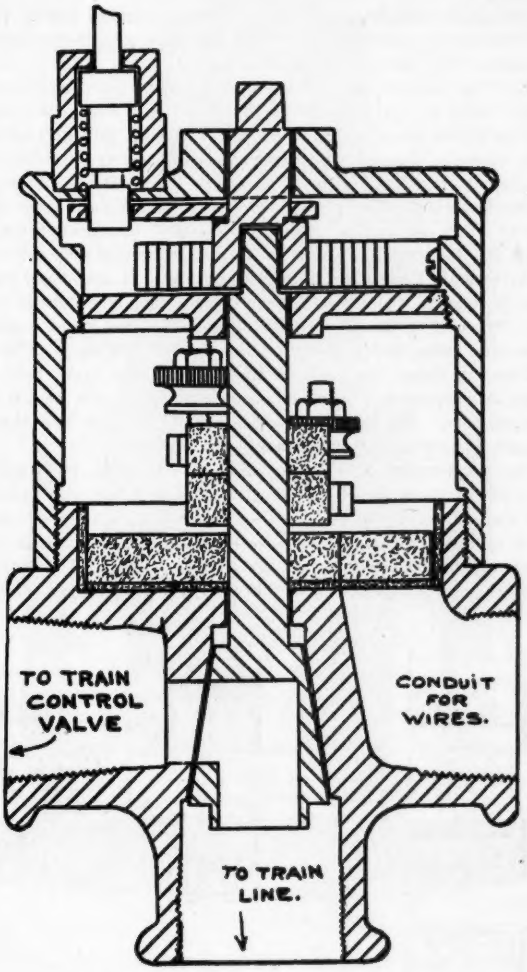


Fig. 5. Cross Section of Cutout Valve.

however, that A. C. could be used as readily or even a combination of the two; that is, A. C. on the track and D. C. on the engine, or D. C. on the track and A. C. on the engine. Also this combined system is adaptable to a road that uses the rails as a part of the return circuit for the propulsion current.

TRACK APPARATUS.

The track apparatus required per block for this combined system consists of a signal mechanism, an insulated short section,

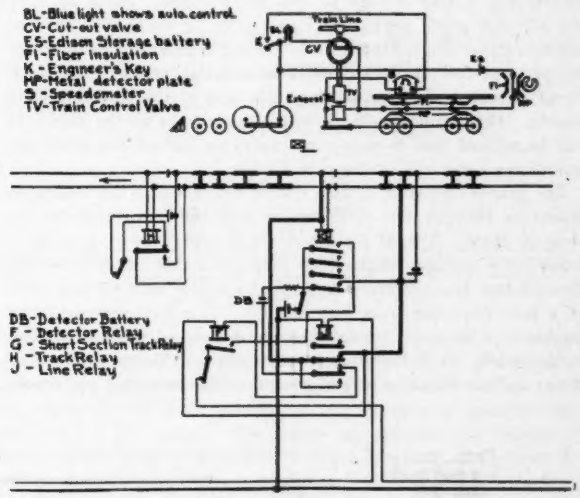


Fig. 6. Diagram of Wiring for Engine Equipped With Train Control.

two polarized track relays, two line relays, a polarized detector relay, two track batteries, a line battery, a detector battery, a small resistance, together with the necessary housing, wires, etc. While on the engine the apparatus consists of an electro-pneumatic valve (train control valve), a cut-out valve, speedometer, storage battery, a push button, a small incandescent light, together with the necessary insulation, wiring, piping, etc.

GROUND APPARATUS.

The ground apparatus for the automatic signal may be any standard make. For the train control, since the rails between the

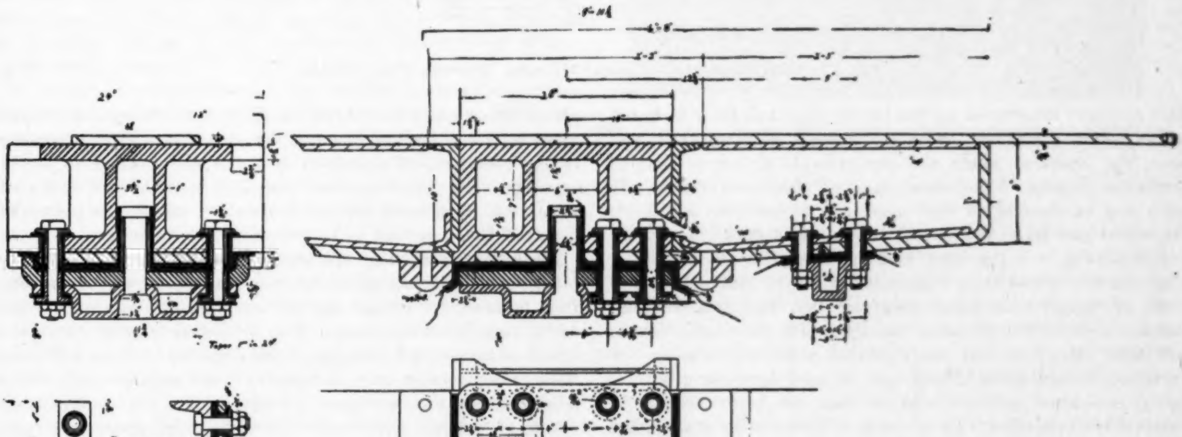


Fig. 7. Cross Section of Body Bolster on Tender of Locomotive, Showing Detector Plate and Fibre Insulation.

engine and the tender are part of the engine circuit, any electrical break in both rails at the same time will deenergize the engine apparatus unless some other path is provided for the engine current.

The two insulated joints at the entrance of the block are placed opposite each other thus causing an electrical break in both rails, while a metallic path is provided around these joints. Two additional insulated joints are placed staggered a short distance in advance, thus making a short relayed section. This section is just long enough to take in an engine. Since the first two of these joints are opposite each other, train control apparatus consisting of a contact in a line relay is arranged to complete the path, or train loop, around these opposite joints if the block ahead is safe, and to break this train loop if the block ahead is unsafe. This train loop is shown in heavy lines on the plan. It will be noticed that it runs from the upper rail of the short section to the lower rail of the rear section.

The proper operation of this system requires that the insulation resistance between the short section and the rear block be five ohms or above. For, if the resistance is broken down to a value below this, current might then flow from the engine battery through this low resistance to hold closed the train control valve at a time when the train loop is open. This low resistance may be due to a worn out insulated joint or some of the wire crossed or grounded. It is therefore necessary to provide some means of detecting this condition and at the same time maintain protection.

ENGINE EQUIPMENT.

The engine equipment consists of insulated tender trucks and draw-bar, train control valve, cut-out valve, battery, speedometer, engineman key, and an incandescent light.

The train control valve is a balanced electro-pneumatic valve having relay points attached to its armature. When energized it holds closed an exhaust port in the train line, said port being open whenever the valve is deenergized. Thus any interruption of current causes a brake application. The cut-out valve is operated mechanically by hand and is accessible only from the ground. It is a two-way cock with two sets of electrical contacts. When in its normal position it furnishes free passage of air from the train line to the train control valve. It also closes contacts to complete the circuit for the incandescent blue light in the cab. When it is closed, it shuts off air from the train control valve, also both electrical contacts are opened. When in a mid-position, it closes the lower contact but at the same time it opens an exhaust port so as to insure that it will not be left in that position. The valve is latched in both the open and closed position to prevent it being changed by vibration.

The speedometer is any standard type to which is attached electrical contacts, so set that they are closed at a speed between one and fifteen miles per hour. The contact is open at zero speed to insure against a dangerous condition arising should the speedometer fail to indicate for any reason whatever. The engineman's key is a common push button. The small blue light is

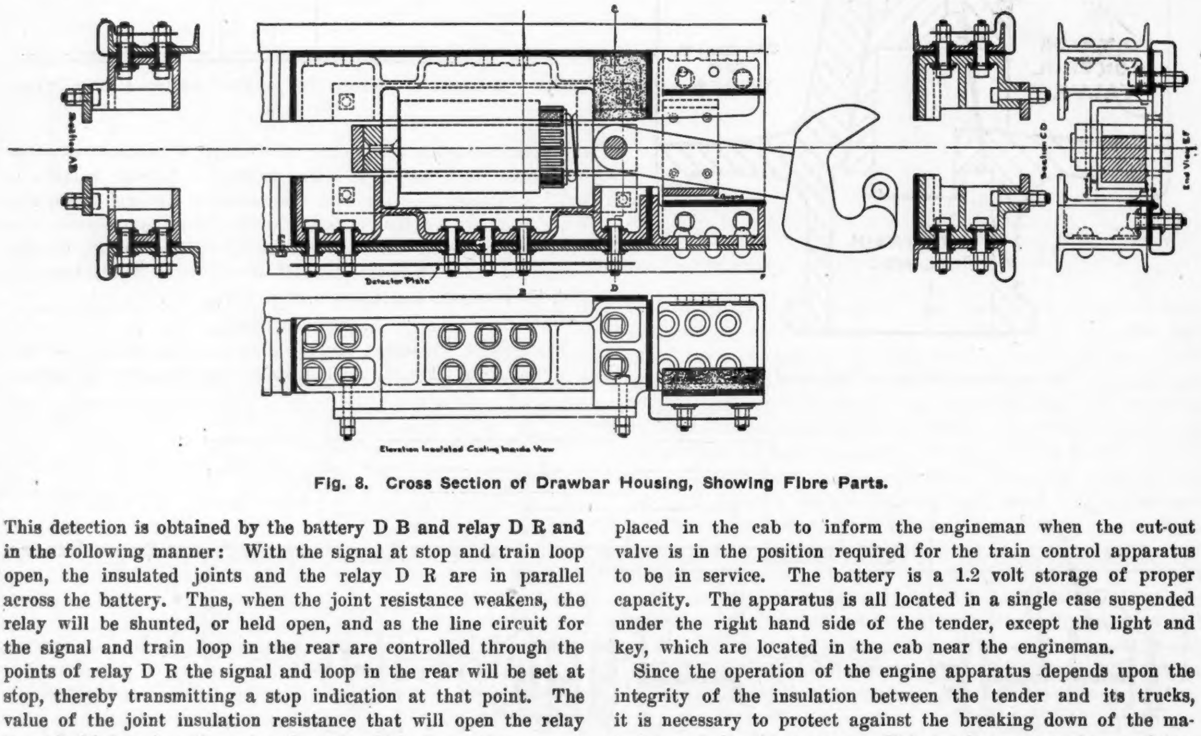


Fig. 8. Cross Section of Drawbar Housing, Showing Fibre Parts.

This detection is obtained by the battery D B and relay D R and in the following manner: With the signal at stop and train loop open, the insulated joints and the relay D R are in parallel across the battery. Thus, when the joint resistance weakens, the relay will be shunted, or held open, and as the line circuit for the signal and train loop in the rear are controlled through the points of relay D R the signal and loop in the rear will be set at stop, thereby transmitting a stop indication at that point. The value of the joint insulation resistance that will open the relay is made higher than the value through which the engine current will flow. However, with the signal at proceed or caution, the relay only is across the battery and no joint detection given. It being considered sufficient and in fact the better method to detect a low insulation resistance only at a time when it is desired to transmit a stop engine indication to a passing engine, that time being when the signal is at stop and the loop open. A small resistance is placed in the detector circuit and located on the heel of the short section track relay inside the relay case under seal. This controls the flow of current from the detector battery and is so located as to prevent any possibility of the resistance being shunted. The track relays as well as the D R are polarized so as to insure that all batteries are in proper relation to each other to give maximum joint detection.

placed in the cab to inform the engineman when the cut-out valve is in the position required for the train control apparatus to be in service. The battery is a 1.2 volt storage of proper capacity. The apparatus is all located in a single case suspended under the right hand side of the tender, except the light and key, which are located in the cab near the engineman.

Since the operation of the engine apparatus depends upon the integrity of the insulation between the tender and its trucks, it is necessary to protect against the breaking down of the material used for this purpose. This insulation is made up of two sheets of fibre with a metal plate called the detector plate between them. This detector plate is included in the engine circuit, and is so placed that any leakage of current through the insulation will shunt the winding of the train control valve and cause it to open. The center plate, side bearing, chain hangers, and draw bar are all insulated in this same manner. The detector plate is connected under the bolt heads so that every bolt is electrically connected into the system, and becomes part of the detection against injury to the insulation.

Furthermore, the speedometer frame and the metal part of both the cut-out and train control valves are included in this detector circuit so as to prevent the possibility of any wire becoming grounded and thus causing a false clear engine indication.

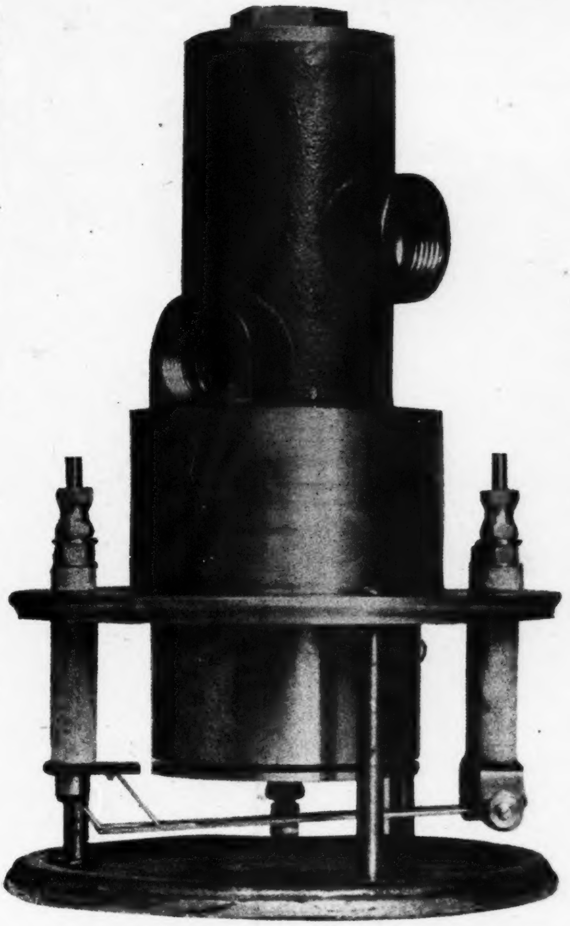


Fig. 9. Train Control Valve.

In regard to the service of the insulated tender trucks and draw bar, it can be said the test engine on the Pennsylvania Lines West was insulated and placed in service in February, 1912. It has since been in regular passenger service, and judging from its performance up to July, 1914, it may be asserted that in insulating a tender it is in no way mechanically weakened nor is its yearly mileage lessened.

In describing the operation of this combined automatic signal and train control system, the operation of the signals need not be mentioned other than to say that with a full block overlap there is always behind a train two signals at stop and a third signal at caution. In describing the train control let it be assumed that the engine is ready to leave the round house and that the train control is to be cut into service. The engineman holds his key closed and at the same time the cut-out valve is unlatched and turned to its normal or running position. In so doing, air is admitted to the train control valve and its coil is energized and the stick point of the train control valve closed, also the blue light is lighted. The engine apparatus is now in running condition. This condition will exist as long as everything is normal. Such an engine is shown in Fig. 1, which, let it be assumed, approaches and passes the proceed signal shown in advance of Fig. 1. As soon as the first pair of wheels passes into the short section, the 12-ohm relay will be shunted, which in turn will break the signal circuits and that for relay D R and the second position line relay in the rear. When the engine passes on so that the opposite insulated joints are between the last pair of engine wheels and the first pair of truck wheels, it will be found that the engine current can flow around these joints by means of the train loop. Thus the engine travels on uninterrupted.

Let us see how a stop engine indication would be received

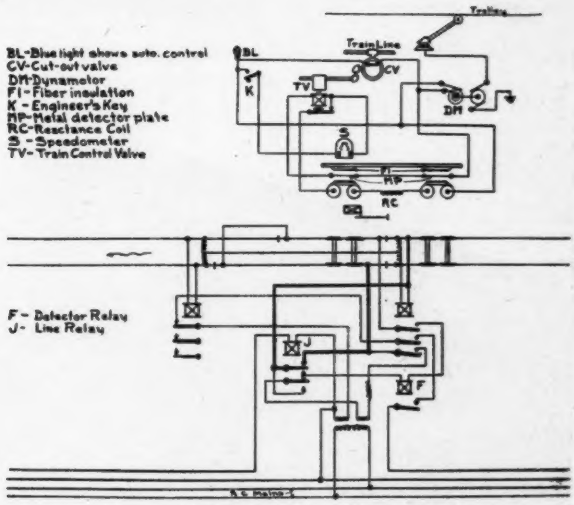


Fig. 10. Electric Railway Wiring Diagram.

should an engine attempt to pass a stop signal at which the loop is open (See Fig. 2). When the opposite insulated joints come between the engine wheels and the truck wheels it is evident that the engine circuit will be ruptured, as the loop is open at the point of the line relay. This causes the armature of the train control valve to drop (See Fig. 2), and having a stick point it will remain down until energized over some other circuit other than the original. Upon the deenergization of the train control

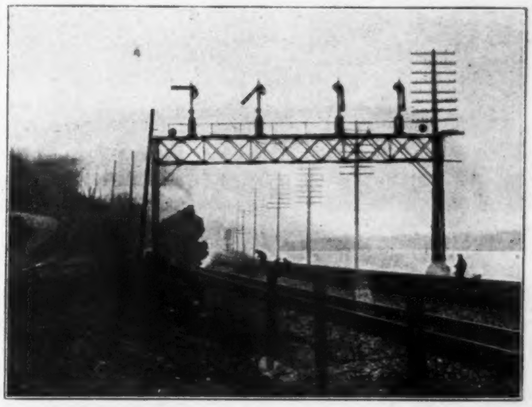


Fig. 11. Train Passing Stop Signal, 45 Miles Per Hour, Automatically Stopped in 1,000 Feet.

valve, air pressure from the train line escapes to the atmosphere and thereby causes an application of the brakes.

There are two ways whereby the brakes may be released: first:—after the train has reduced speed sufficiently so that the electrical contacts of the speedometer are made, the engineman by closing his key can reenergize the train control valve; second:—after the train has come to a full stop, it can be released by the fireman going to the cut-out valve and turning it back to its mid position. The train control valve can then be reenergized in the same manner as it was at the round house.

By tracing out the engine circuit it will be found that as long as the speedometer contacts are made (that is, the speed is between one and fifteen miles per hour), the engine can pass a stop signal without the train control applying the brakes.

Also, by the closing of the speedometer contacts at low speed, the possibility of undesirable engine stop due to the use of sand is entirely obviated. The same may also be said of low speed switching or siding movements.

In conclusion, it is asserted that the Gray-Thurber train control is based upon a sound fundamental principle and it has been

RAILWAY ENGINEERING AND MAINTENANCE OF WAY

[November, 1914]

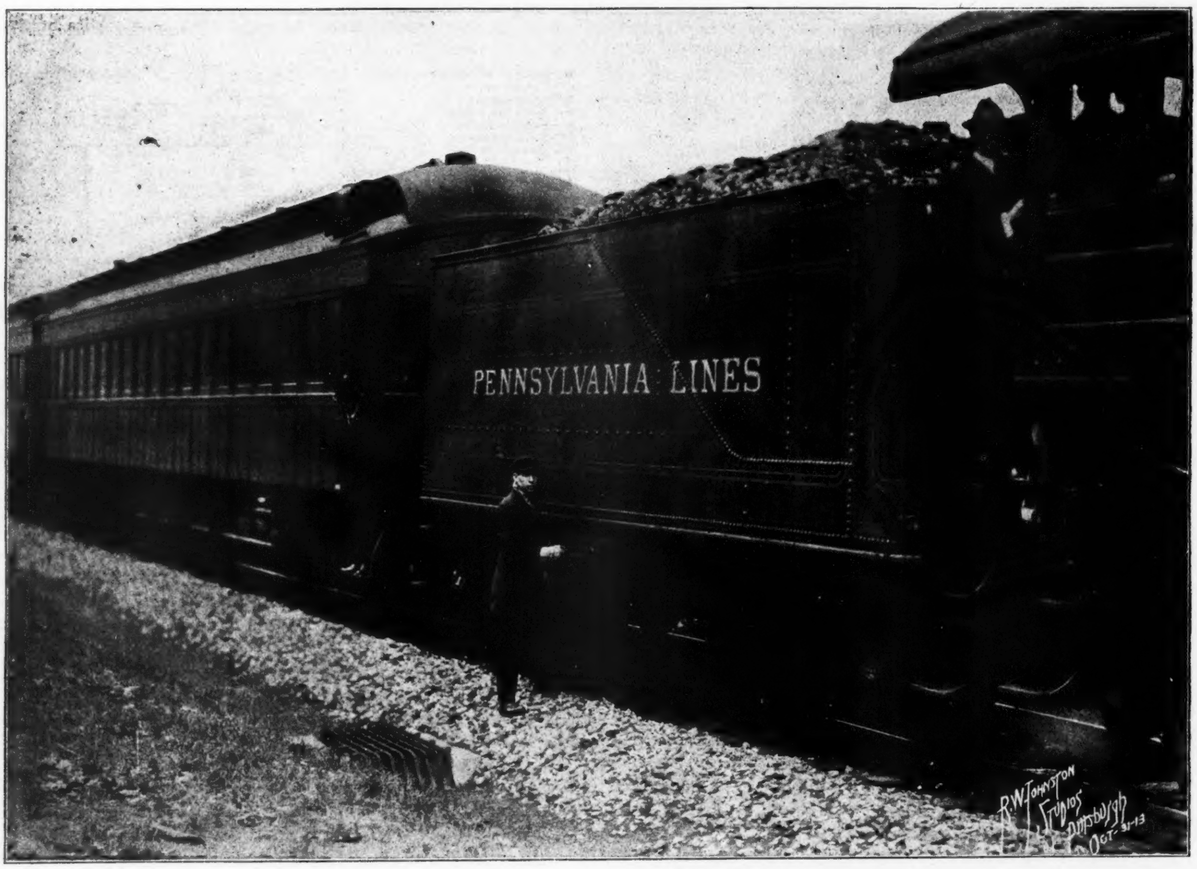


Fig. 12. Fireman Releasing Brakes After Train Automatically Stops, When Stop Signal Was Passed.

proven that it is practical both from the standpoint of safety and service, and there is no apparent reason why it cannot be readily applied as an adjunct to any present or proposed signal system.

REQUIREMENTS OF THE JOINT A. R. A. COMMITTEE.

The following description shows the application of the Gray-Thurber System of Train Control to meet the requisites of the Joint A. R. A. Committee as reported at the meeting of May 20, 1914.

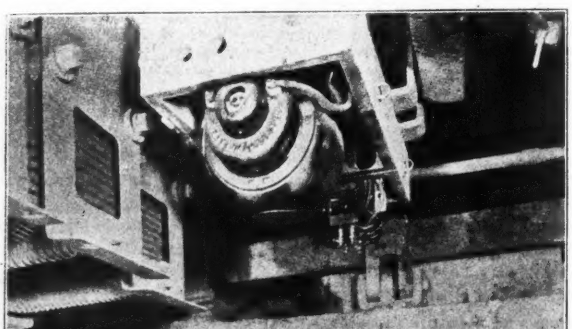


Fig. 13. Dynamotor and Transformer Fastened Beneath Car. System Applied to Electric Railways.

"Automatic Train Control."

"An installation so arranged that its operation will automatically result in either one or the other or both of the following conditions.

"First—The application of the brakes until the train has been brought to a stop."

With this condition it is necessary to read another condition. "Upon entering occupied or dangerous territory." Now current for energizing the engine apparatus will be cut off upon entering an occupied or dangerous block and rupturing the engine current causes an application of the brakes which cannot be released until the train has come to a full stop.

"Second—The application of the brakes when the speed of the train exceeds a prescribed rate and continued until the speed has been reduced to a predetermined rate."

If the same modifying clause ("upon entering occupied or dangerous territory") is used with this condition, the manner of taking care of the condition is made simple by electrical contacts on a speedometer which are closed below some prescribed speed. When closed, these contacts furnish a circuit for reenergizing the engine apparatus so as to release the brakes after same being applied to an engine entering a dangerous block. However, if the above condition refers to a maximum speed, this condition can be met by electrical contacts that are closed at all times except when this maximum speed is exceeded, at which time the circuit would be broken and the brakes applied.

"Requisites of Installation."

"Note—These requisites are drawn for application in connection with a properly installed block signal or interlocking system."

(1) "The apparatus so constructed that the failure of any essential part will cause the application of the brakes."

This system being designed entirely on the closed circuit principle, the presence of the energizing agent both on the engine and

on the track is required at all times, and anything preventing the presence of this agent will cause an application of the brakes.

(2) "The apparatus so constructed that it will automatically control the train in the event of failure by engineman to observe signals or speed regulations."

The train control equipment being operated directly by the track circuit of the block in advance of the moving train, any condition arising which automatically sets the signal at "stop" will also automatically apply the brakes to a train as it enters the danger zone.

(3) "The apparatus so constructed that it will control the train in the event of a failure of fixed signals to give proper indications."

The train control circuits are controlled through a point of the track relay, so that in case the track circuit is interrupted by the presence of a train or some other dangerous condition, the train control circuit is interrupted, thereby stopping any following train, whether the fixed signal has operated or not.

(4) "The apparatus so constructed that proper relation between those parts along the roadway and those on the train will be assured under all conditions of speed, weather, wear, oscillation and shock."

The application of this device requires nothing added to the roadway nor any portion of the apparatus extending from the vehicle, as the current required for operation goes to the rails through the engine wheels and leaves rails by way of the tender wheels. The weather has no more effect than it has on automatic signals. Speed, wear of track or oscillation have no effect on contact between wheels and rail. Shock is taken care of by suitably supporting the engine apparatus. There is no reason why this system will not operate wherever and whenever an automatic signal system will operate.

(5) "The train apparatus so constructed as to prevent the release of the brakes after automatic application has been made until the train has been brought to a stop or the speed of the train has been reduced to a predetermined rate."

The cut-out valve is used to release the brakes, and this valve is placed at some location accessible only from the ground. Thus it will not be possible to release the brakes until the fireman is able to reach this valve. However, by making use of electrical contacts on a speedometer, it is possible to permit an engine to pass a stop signal at slow speed without an application of the brakes.

(6) "The train apparatus so constructed that when operated it will make an application of the brakes sufficient to stop or control the train within a predetermined distance."

Upon the size of the exhaust port depends the severity of the brake application. By properly adjusting this exhaust port, a service application can be obtained that will stop the train within the regular braking distance, without shock to passengers or equipment.

(7) "The apparatus so constructed as not to interfere with the application of the brakes by the engineman's brake valve or the efficiency of the air-brake system."

The train control brake apparatus is connected directly into a branch of the train line, and therefore does not interfere in any way with the operation of the engineer's brake valve or the efficiency of the air brake system.

(8) "The apparatus so constructed as to be operative when the engine is running forward or backward."

There being no connection between any battery along the right of way and the engine battery, there is nothing to prevent proper operation of this train control whether the engine is running forward or backward.

(9) "The apparatus so constructed that when two or more engines are coupled together or a pusher is being used the apparatus can be made effective on the engine only from which the brakes are controlled."

There is nothing about this system to prevent two engines being coupled together and either being the controlling engine. In the event of a pusher being used, the pusher will not have its brakes applied.

(10) "The apparatus so constructed as to be operative on trains moving only with the current of traffic."

In this system the loop circuit, for engine current at the time of passing the opposite joints, is made the controlling agent of the engine. If this loop circuit is complete through a point of the line relay, the engine passes, if not complete; that is, if line relay is open, then the brakes are applied. With this in mind, it is seen that an engine can run against traffic without being stopped as long as the line relays are closed.

(11) "The apparatus so constructed as to conform to the American Railway Association standard of clearance of rolling equipment and structures."

This system requires absolutely nothing on the roadway, and the engine equipment is all installed in a small box suspended beneath the center of the tender, the same as car lighting battery. All of which meets the A. R. A. clearance standards.

(12) "The apparatus so constructed as not to constitute a source of danger to employees or passengers, either in its installation or operation."

In this system there is absolutely nothing added to roadway or to vehicle, but a small box under the tender about two feet square for holding instruments. This could constitute no menace to trainmen or passengers.

Fig. 14. Electric Car Equipped With Automatic Control. Conductor Releasing Brakes When Set by System.

(13) "The apparatus so constructed as not to interfere with the means used for operating fixed signals."

All train control apparatus is electrically operated from a separate point of the track or line relay, and not mechanically connected with the signal. This would make the train control operation entirely independent and, therefore, could not interfere with the fixed signals.

ADJUNCTS:

(a) "*Cab Signal.*—A signal located in the engine cab indicating a condition affecting the movement of the train and so constructed that the failure of any part directly controlling the signal will cause it to give the 'stop' indication."

In its present form, this system gives no indication other than the application of brakes or absence of application of brakes as the case may be, depending on whether or not the engine relay is tripped. The original plan of this system and the first engine equipped and which was tested for about six months, carried on the engine a three-position semaphore indicator, indicating the position of the signals as passed, both by position of semaphore and by colored electric lamps.

This cab signal was eliminated at the request of the Block Signal and Train Control Board about February 1, 1912, but it can be easily added again if desirable.

(b) "*Detonating Signal Apparatus.*—An apparatus located along the roadway and so constructed as to give an audible signal by means of a torpedo or other explosive cartridge."

No attempt has been made by the Automatic Train Control and Signal Company to produce audible fixed signals.

(c) "*Speed Indicator.*—The speedometer mentioned in bulletin No. 8 has a speed indicator attachment and can be supplied is desired."

(d) "*Recording Device.*—An apparatus located on the train and so constructed as to make a record of the operations of the automatic application of the brakes and of the speeds of the train, and such other records as may be desirable."

On one of the engines which was equipped with the complete Gray-Thurber Train Control and Cab Signal System a recording clock was arranged to move a tape so that there was made a record of the time during which the engine was not under automatic control marked on tape "air cut off," and record of the time and kind of each signal (danger or caution) received, regardless of speed. Also a record if the brakes were automatically applied. This clock was removed from the original plan by the old Block Signal and Train Control Board, but it can easily be added again if desirable.

The above explanation describes in what way the Gray-Thurber System conforms or can be made to conform with the requirements and adjuncts as above set forth.

Personals

E. N. Brown has resigned as president and director of the *National Railways of Mexico.* It is understood that Louis Cabrera will succeed him. Mr. Brown offered to retire from the presidency of the road at the time of the overthrow of the Madero regime.

F. A. Lehman, assistant to vice-president, operation, of the *Atchison, Topeka & Santa Fe Ry.*, has been appointed general superintendent of Eastern lines, Western district, with headquarters at Newton, Kan., and Edward Raymond, the present general superintendent at Newton, takes Mr. Lehman's place at Chicago. The change, which is understood to be a temporary arrangement, is effective November 1.

T. J. Kennedy has been elected president and general manager of the *Algoma Central & Hudson Bay Railway Co.*, and the *Algoma Eastern Railway Co.*, with headquarters at Sault Ste. Marie, Ont.

F. G. Altiearn has been appointed vice president of the *Amador Central* with headquarters in San Francisco.

E. W. Grice has been promoted from assistant general manager to assistant to president, of the *Chesapeake & Ohio*, with headquarters at Richmond, Va.

J. M. Rapelje, assistant general manager of the *Northern Pacific Ry.*, lines east of Paradise, Mont., has been appointed general manager of those lines, with headquarters at St. Paul, Minn., vice G. A. Goodell, deceased.

C. C. Walker, assistant to general manager of the *Chesapeake & Ohio Ry.* at Richmond, Va., has been appointed superintendent of passenger transportation, and E. P. Goodwin, superintendent of transportation at Richmond, has been appointed superintendent of freight transportation, both with headquarters at Richmond, Va.

W. T. Tyler has been appointed superintendent of the Pasco division of the *Northern Pacific Ry.*, with headquarters at Pasco, Wash., effective October 15, succeeding T. E. Coyle, resigned.

J. W. Everman, general manager of the *St. Louis Southwestern* of Texas, has been elected first vice-president and general manager, and first vice-president of the *Stephensville North & South Texas*, with headquarters at Tyler, Tex.

P. E. Clark, vice-president of the *Tennessee, Kentucky & Northern*, has been elected president, succeeding George A. Clark, deceased, and T. C. McCampbell, general auditor, succeeds P. E. Clark as vice-president; both with headquarters Nashville, Tenn.

H. Adkins, general superintendent and chief engineer of the *Tennessee, Kentucky & Northern*, has been appointed general manager, with headquarters at Nashville, Tenn.

W. P. Kimble, division engineer of the *Erie Railroad* at Marion, Ohio, with jurisdiction over the division between Kent and Dayton, has been transferred to the *Marion-Dayton* division. R. H. Boykin, formerly supervisor of the Third division, between Kent and West Salem, Ohio, with office at Marion, is made division engineer between Marion and Kent; K. W. Collister, supervisor in the Fourth division, at Marion, has resigned.

A. C. Bradley has been appointed division engineer of the Oklahoma division of the *Chicago, Rock Island & Pacific* at El Reno, Okla., in place of Garret Davis, who has been promoted to a position in connection with the valuation work, with office in Chicago.

J. D. Lovell, supervisor of the *Pennsylvania Railroad* at Tyrone, Pa., has been transferred as supervisor to East Brady, succeeding W. S. Johns, Jr., transferred. R. R. Nace, supervisor at Buffalo, N. Y., has been transferred as supervisor to the office of the valuation engineer at Philadelphia, Pa. J. S. Considine, supervisor at Driftwood, Pa., succeeds Mr. Nace. H. S. Trimble, supervisor at Irvona succeeds Mr. Considine, and R. A. Klein, supervisor of the *Camden Terminal* division and the *West Jersey & Seashore* at Camden, N. J., succeeds Mr. Pitcairn. A. E. Preble, supervisor of the *Cumberland Valley* at Chambersburg, Pa., succeeds Mr. Klein, and N. B. Pitcairn, supervisor at Verona succeeds Mr. Preble.

With The Manufacturers

MANN FRONT CENTER SPREADER.

The Mann ballast spreader, which has been illustrated in these columns heretofore, is now made to include a front center spreader as desired. This front spreader may be furnished and applied at minimum cost if not included in the original equipment.

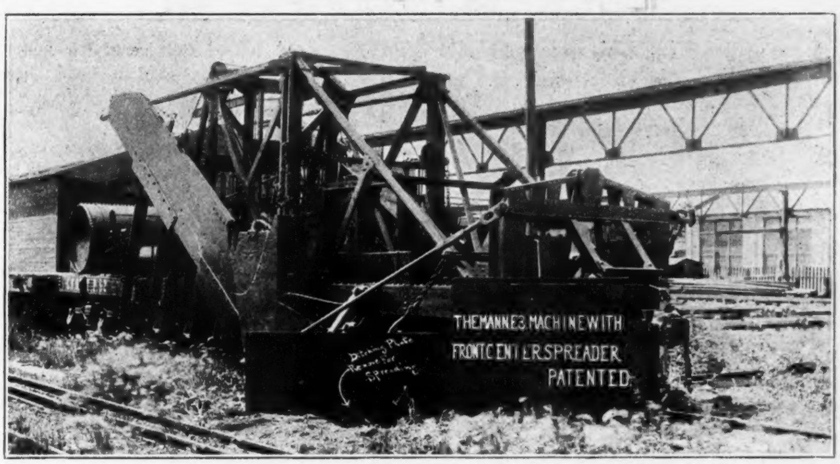
The front spreader, like the rest of the machine, is built to withstand the most severe service. It cuts four inches below the top of the rail and is raised vertically by the same two cylinders which operate the side wings; although it can be used with or without either or both side wings. One air cock serves to operate both side wings and the front spreader. In case the side wings are not needed, they are simply left in their raised position, flat against the sides of the car. The side wings spread any distance up to ten feet from the track center and a ditching plate may be placed to cut a ditch at any point up to ten feet from the center of the track. These operations can be performed at a speed of five miles per hour.

This machine will carry material when irregularly deposited in unloading, making equal distribution. Material for building a bank can also be brought up from a position 8 inches below the top of the ties; the slope is made regular and true to dimensions by the same operation. Material is not wasted down a fill because of the carrying feature, the surplus being carried to the low points and fed out as needed.

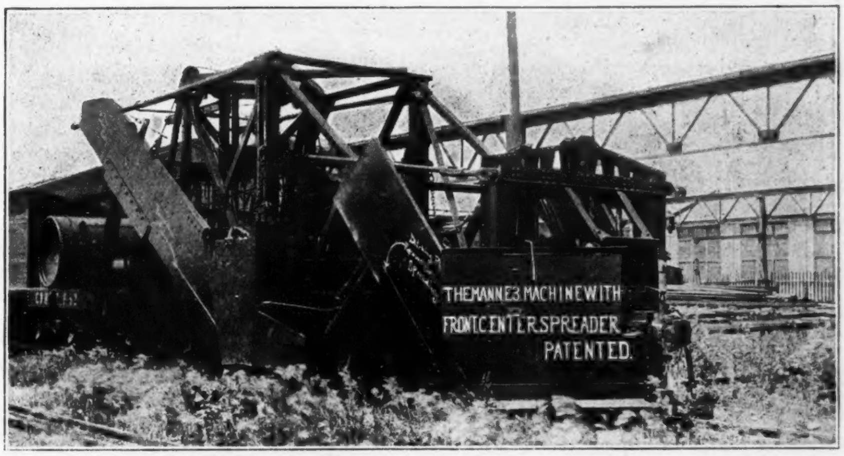
All attachments can be folded inside clearance limitations in ten seconds and put back in service as quickly. This feature is important where live track is being worked and where traffic must not be hindered. The machine is sold by the Mann-McCann Co., Transportation Bldg., Chicago.

THE SCHOOP METAL SPRAYING PROCESS.

A radical development in metal-working methods is the new Schoop metal-spraying process, which is now being placed in the hands of the public. Briefly, the process consists of reducing metallic wire to impalpable dust by means of an oxy-hydrogen flame and then forcing these metallic particles with great velocity against the surface of the object to be coated. The particles then imbed themselves in the surface of the piece to be plated and homogeneously unite with the succeeding particles that are pro-



Mann Spreader. Ditching Plate in Place for Action.



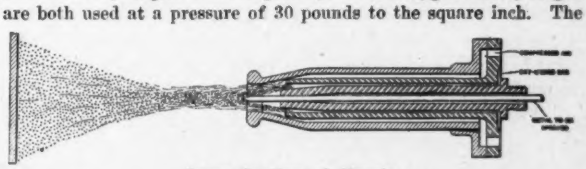
Ditching Plate Lifted to Allow Front Spreader to Operate.

jected upon them. The result is an even coating of deposited metal, adhering to the coated object. The deposited metal is amorphous and not crystalline in its structure, and more dense than the wire from which it came. The spraying is done by the special torch or pistol shown in Fig. 1, the wire being fed into the pistol from one side and emerging at the torch end in a fine spray. By means of this process, it is possible to coat metal, wood, paper, cloth, stone, cement and other substances with lead, tin, zinc, aluminum, copper, brass, bronze, German silver, gold and even steel. It is the only known method of plating with aluminum and steel.

DETAILS OF THE PROCESS.

The mechanism within the pistol serves the purpose of feeding the wire into the nozzle of the torch as indicated in Fig. 2, which best illustrates the action of the process. The nozzle consists of three tubular parts; the inner part that acts as a guide for the wire; the middle section which, in conenction with the inside part, forms a conducting tube for the oxy-hydrogen gas; and the outer part, or nozzle proper, which forms a protecting case, and which, in connection with the middle section, forms a tube through which the compressed air is led to the projecting point. The metal wire is fed forward just fast enough to allow it to be disintegrated by the flame and carried to the work by the air blast, the metallic dust being held in suspension in the expanding gas, and carried forward by the air pressure. The wire used is from 0.030 to 0.040 inch diameter and is fed forward at a speed of from ten to eighteen feet per minute—the metals that melt at high temperatures being fed the slowest to allow the flame more time for disintegration.

The oxygen and hydrogen may be supplied from standard commercial tanks, but when the process is worked on a large scale it is advisable to make the gas on the premises for the sake of economy. The tank pressure of the oxygen is 120 atmospheres and of the hydrogen 20 atmospheres, but the oxygen and hydrogen are both used at a pressure of 30 pounds to the square inch. The

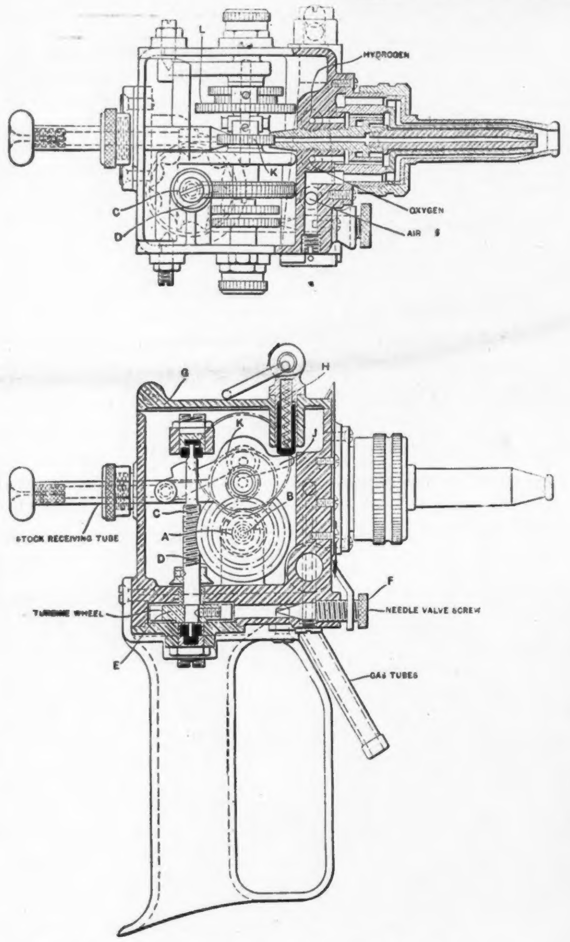


Cross Section of Nozzle.

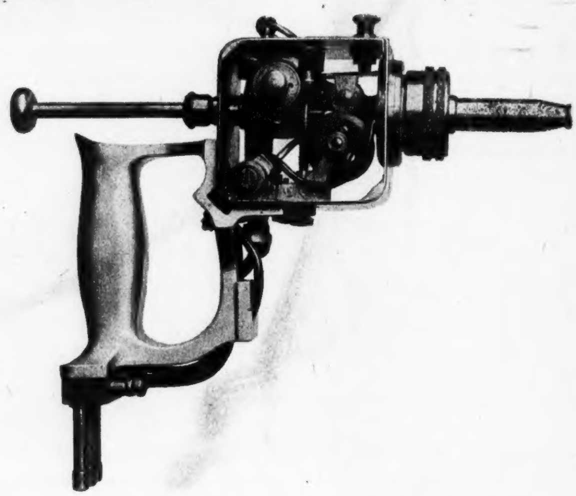
compressed air is of 100 pounds pressure and is used at the rate of 35 cubic feet per minute. It is important that the proportions of oxygen, hydrogen and air be adjusted for each of the metals used, and that the wire feed be of the right speed in proportion to the flame.

THEORY OF THE DISINTEGRATING AND COATING ACTION.

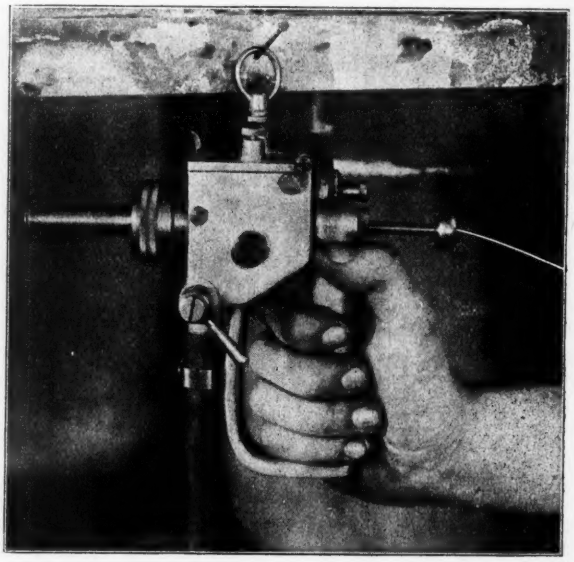
One of the most singular facts relative to this process is that the metal is not applied in a molten state. The correct operating distance is from five to six inches from the pistol point to the work. At this distance a piece of paper or even a match may be coated without danger of ignition. The spray may be directed at the hand without injury. The reason for this is that the gaseous medium is so much larger in volume than the drop of metal reduced to a powder, that the expanding gas cools the metallic spray before it strikes the surface to be coated. The heat of collision, however, causes the particles to vaporize and condense



Cross Sections of Pistol Showing Detail Construction.



View of Pistol, With Side Cover Plates Removed.



Pistol Complete for Service.

on the relatively cold surface and thus form a homogeneous coating. In addition to the union of the projected particles themselves, the first ones to strike the surface are driven into the pores of it.

The surface produced by this process is granular in appearance; it resembles a sand-blasted surface and on this account does not lend itself readily to polishing, and the process is not recommended where a high finish must be obtained. By proper treatment in the polishing room, however, a well finished surface can be secured. There is no tendency toward peeling or flaking when polishing.

THE SPRAYING MECHANISM.

The spraying pistol has but two functions to perform—the leading of the air and gases to the spraying point and the feeding of the wire. The gas tubes, one for oxygen and one for hydrogen, and the air tube, are placed side by side, having proper connection with the concentric tubes in the nozzle.

The wire feed is operated by an air-driven turbine. Entering the pistol box through the stock receiving tube, the wire passes to a pair of toothed feed-wheels that propel it straight forward to the nozzle. The lower feed-wheel *A* is mounted on the main shaft *B*. This shaft is driven by a worm and worm-wheel *C* and *D*. The worm-shaft has at its lower end a turbin wheel *E* mounted in ball bearings. This wheel is driven by air from the main supply tube and its speed, and consequently that of the wire feed, is governed by the amount of air that enters through needle valve *F*. A shut-off valve cuts off the air completely when the pistol is not in operation. It is provided with two spring plungers *H;* when the lid is down, these plungers bear against bracket *J* that carries the upper feed-wheel *K* and the driving gear *L*. Opening the lid for inspection, releases pressure on bracket *J* and prevents the wire from feeding. Beside gear *L* are two other gears used with corresponding pinions for speed changes. These comprise the principal parts of the pistol.

COST OF SPRAYING METAL.

An operator can apply the metal to objects at the average rate of one square foot per minute. On soft metals the coat can be applied at twice that speed, with steel or nickle the time would be longer. A pound of lead can be sprayed in less than a minute. The total cost of spraying with soft metals, coating the work about 0.001 inch thick is less than two cents per square foot. This includes metal, labor and gases at "small-quantity" prices. After the first cost of installation of a portable pneumatic and oxy-hydrogen plant railways would be able to coat or paint all structures, bridges, signal masts, signal connections, etc., much cheaper per square foot than it is now costing, with a more satisfactory and even job, and in 60 per cent of the time now required.

The Metals Coating Co., of America, People's Gas Building, Chicago, Ill., controls the rights of this process in the United States. This concern issues licenses for the use of the process and leases the spraying pistols.